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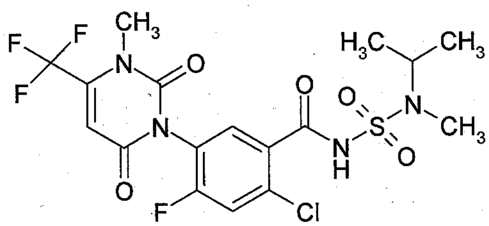
United States
Environmental Protection
Agency

Environmental Fate and Ecological Risk Assessment for the Registration of the New Chemical Saflufenacil (BAS 800 H)



Saflufenacil

CAS 372137-35-4 PC Code 118203

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1. Executive Summary

1.1. Nature of Chemical Stressor

Saflufenacil, also known as BAS 800 H, is a new contact and residual herbicide in the uracil class of compounds that is absorbed by roots and foliage and has limited systemic activity. The compound belongs to the mode-of-action Group 14/Group E, meaning that it inhibits protoporphyrinogen-oxidase (PPO) in the heme and chlorophyll biosynthetic pathway, resulting in disruption of chlorophyll and heme synthesis and the accumulation of protoporphyrins. In the presence of light, protoporphyrins produce activated oxygen species that rapidly disrupt cell membrane integrity. Saflufenacil is proposed for use on broadleaf weeds via pre-plant and pre-emergence applications to cereal small grains, corn, chickpeas, cotton, edible beans, edible peas, lentils, lupine, sorghum, soybeans, and sunflowers; via post-emergence applications to fruit tree orchards, nut tree orchards, and vineyards; and via applications to fallow croplands and non-agricultural areas, including pine plantations, rights-of-way, bare ground, and Christmas tree plantations. Saflufenacil is also proposed for use as a desiccant and/or defoliant on sunflowers.

Five end-use formulations of saflufenacil are proposed for registration in the United States. These include BAS 800 04H (29.74% a.i.), an aqueous suspension concentrate (SC) for agricultural crop and fallow land uses; BAS 804 00H (17.80% a.i.), a water soluble granule (WG) for agricultural uses containing 50.20% imazethapyr; BAS 781 02H (6.24% a.i.), an emulsifiable concentrate (EC) for agricultural uses containing 55.04% dimethenamid-p; BAS 800 01H (70.0% a.i.), a water soluble granule (WG) for orchard and vineyard uses; and BAS 800 02H (12.27% a.i.), an emulsifiable concentrate (EC) for non-agricultural uses.

The proposed maximum single and annual application rates for saflufenacil are the same, at 0.356 lbs a.i./A on non-agricultural areas (BAS 800 02H). BAS 800 04H and BAS 800 01H have a proposed maximum annual application rate of 0.134 lbs a.i./A for selected agricultural crop, orchard, and fallow land uses. The multi-active ingredient products, BAS 804 00H and BAS 781 02H, have lower proposed maximum annual application rates for labeled uses, but include directions not to exceed an annual rate of 0.134 lbs saflufenacil per acre from all sources of the chemical.

1.2. Potential Risks to Non-target Organisms

The results of this assessment indicate that the proposed uses of saflufenacil have the potential for direct adverse effects on listed and non-listed mammals (based on chronic exposure associated with non-agricultural use patterns) and listed and non-listed terrestrial plants (based on all proposed use patterns). Based on the available data, risk for direct adverse effects to terrestrial invertebrates is considered low for saflufenacil and all formulations with the exception of BAS 781 02H. It is possible that direct risks to terrestrial invertebrates, including beneficial insects, may occur, based on exposure to the BAS 781 0H2 formulated product used on corn and grain sorghum. Although risks to aquatic organisms are predicted to be minimal based on the baseline-level assessment, there is uncertainty associated with this risk conclusion for aquatic animals because saflufenacil is classified as a light-dependent peroxidizing herbicide (LDPH) and photo-enhanced toxicity is a possibility. In order to address this uncertainty, an interim enhanced toxicity adjustment factor has been applied to the available saflufenacil chronic fish early life-stage data collected under normal laboratory lighting, based on studies conducted under modified light for another chemical in the LDPH class, oxyfluorfen (CAS No. 42874-03-3). The results of this analysis indicate that risks to aquatic vertebrates are still expected to be low. Saflufenacil would have to be approximately 3 times more toxic under modified light in order to cause risk concerns for aquatic vertebrates.

The AgDRIFT model was used to predict potential spray drift buffers that may be protective of listed and non-listed terrestrial plants. The results of this analysis indicate that risk to listed species of plants cannot be reasonably mitigated for aerial and ground applications because predicted drift distances exceed the limit of the AgDRIFT model. Spray drift buffers ranging from 453 to 748 feet would be needed to protect non-listed plants from ground applications of saflufenacil at application rates ≤ 0.045 lbs a.i./A; protective buffers for non-listed plants for ground applications at rates >0.045 lbs a.i./A also cannot be derived because they also exceed the limits of the model. In addition, it should be noted that there may be concern for more sensitive plant species or cultivars, given that certain EECs associated with the non-agricultural use pattern are very close to the maximum application rates.

Although direct adverse effects to aquatic organisms and birds from saflufenacil use are not expected, indirect effects to all taxa are predicted, based on the potential for adverse effects to terrestrial plants. Potential effects include, but are not limited to, reduction in food resources, decrease in cover, change in water quality parameters, and loss of breeding/nesting habitat.

Potential "may affect" determinations to federally-listed endangered and threatened species (listed species) based on LOC exceedances require an in-depth listed species evaluation of the potential co-occurrence of listed species and areas where saflufenacil is proposed for use on agricultural crops and non-agricultural areas. For the purposes of this assessment, it is assumed that saflufenacil may be used nationwide for non-agricultural uses. Identified potential direct and indirect risks to listed species that may result from the proposed uses of saflufenacil are summarized in **Table 1.1**.

Table 1.1. Potential Effects to Federally Listed Taxa Associated with Direct or Indirect Effects from the Proposed New Uses of Saflufenacil.

Listed Taxon	Direct Effects	Uses of Concern Resulting in Direct Effects	Indirect Effects	Uses of Concern Resulting in Indirect Effects
Terrestrial and semi-aquatic plants - monocots	Yes	All uses	Yes[2]	Non-agricultural
Terrestrial and semi-aquatic plants - dicots	Yes	All uses	Yes[2]	Non-agricultural
Terrestrial invertebrates	Yes[a]	Corn and grain sorghum	Yes[1,2]	All uses
Birds	No	None	Yes[1,2]	All uses
Terrestrial-phase amphibians	No	None	Yes[1,2]	All uses
Reptiles	No	None	Yes[1,2]	All uses
Mammals	Yes	Non-agricultural	Yes[1]	All uses
Aquatic vascular plants	No	None	Yes[1]	All uses

Table 1.1. Potential Effects to Federally Listed Taxa Associated with Direct or Indirect Effects from the Proposed New Uses of Saflufenacil.				
Listed Taxon	**Direct Effects**	**Uses of Concern Resulting in Direct Effects**	**Indirect Effects**	**Uses of Concern Resulting in Indirect Effects**
Freshwater fish	No	None	Yes[1]	All uses
Aquatic-phase amphibians	No	None	Yes[1]	All uses
Freshwater invertebrates	No	None	Yes[1]	All uses
Mollusks	No	None	Yes[1]	All uses
Marine/estuarine fish	No	None	Yes[1]	All uses
Marine/estuarine invertebrates	No	None	Yes[1]	All uses

[a] Risks associated with exposure to BAS 781 02H formulation only.
Potential indirect effects on a taxon attributable to:
[1] direct effects on terrestrial monocot and dicot plants
[2] direct chronic effects on mammals

1.3. Conclusions - Exposure Characterization

Saflufenacil is nonvolatile, hydrophilic, and mobile to highly mobile in soil. The solubility of the compound is pH-dependent; at environmentally relevant pH values, saflufenacil is expected to be ionic. The compound dissipates in the environment through both abiotic and biotic degradation and by leaching and is not expected to persist in aerobic soil (half-life of 1-5 weeks) or alkaline water bodies (half-life of <1 week). Saflufenacil may be moderately persistent in acidic to neutral water bodies (half-life of 4-10 weeks). Terrestrial field dissipation study results are relatively consistent with those of the laboratory studies, showing that the chemical dissipates by degradation and leaching, with dissipation half-lives ranging from 1 to 36 days.

Fourteen major environmental degradates of saflufenacil were identified in submitted studies, M01, M02, M04, M07, M08, M15, M22, M26, M29, M31, M33, TFP, 'product 8', and an unidentified photodegradate, 'unknown 3/2/2'. M01, M02, M08, product 8, and unknown 3/2/2 have an intact uracil ring and are most similar to the parent compound. M04, M07, M15, and M22 have a cleaved uracil ring, but remain structurally similar to the parent compound. M26, M29, M31, M33, and TFP are trifluorinated cleavage products of the uracil ring. All degradates other than M04, product 8, and unknown 3/2/2 were greater than 10% of the applied in at least one biotic degradation study (the others were abiotic degradates). M07, M15, M29, and M33 were major degradates in both biotic and abiotic degradation studies.

1.4. Conclusions - Effects Characterization

Saflufenacil is classified as practically non-toxic to fish and freshwater invertebrates and moderately toxic to estuarine/marine invertebrates on an acute exposure basis. No sublethal effects were observed in any of the acute aquatic animal studies for saflufenacil. The available acute toxicity data for the BAS 781 02H formulation, which contains 6.24% saflufenacil and 55.04% dimethenamid-p, show that it is approximately 3 to 7 times more toxic than parent saflufenacil to freshwater fish, invertebrates, and aquatic vascular and non-vascular plants. Although the BAS 781 02H formulation is more toxic than technical grade, further examination of the available data indicate that dimethenamid-p, not saflufenacil, primarily accounts for the toxicity of this formulation. Chronic exposure to saflufenacil resulted in a 5% reduction in embryo survival in fish and decreased parental survival (30% reduction) and growth (5% reduction) of invertebrates. Benthic sediment toxicity testing with spiked sediment indicates that the compound does not partition to sediment, but rather is associated with the water column. Exposure of benthic invertebrates resulted in a 17% reduction in emergence rate. All available aquatic toxicity data show that the M07 and M08 degradates are less toxic to aquatic animals and plants than parent saflufenacil.

Saflufenacil is classified as practically non-toxic to avian species on an acute oral and subacute dietary-exposure basis. The lowest NOAEC in an avian reproduction study (96 mg a.i./kg diet) was based on a reduction in bobwhite quail hatchling body weight. Saflufenacil is classified as practically non-toxic to mammals on an acute oral basis. A two generation reproduction study on rats resulted in a no observed adverse effect level (NOAEL) of 15 mg a.i./kg-bw/day based on increased pup mortality, reduced weight gain, and anemia. Although no sublethal effects were observed in any of the acute terrestrial animal studies for saflufenacil, it is important to note that sublethal effects including anemia and hematologic effects, which are consistent with the LDPH mode of action, were observed in the chronic mammalian study. Saflufenacil is classified as 'practically non-toxic' to non-target terrestrial insects.

Results of the Tier II seedling emergence and vegetative vigor studies with the BAS 800 01H and BAS 800 02H formulations indicate that dicotyledonous plants (dicots) are more sensitive than monocotyledonous (monocots) in the vegetative vigor test, and dicots are more sensitive to foliar routes of exposure in the vegetative vigor test than the seedling emergence test. Monocots appear to be more sensitive in the vegetative vigor test for the BAS 800 02H formulation and more sensitive in the seedling emergence test for the BAS 800 01H formulation. However, all tested plants exposed to both formulated products, with the exception of wheat and bean in the seedling emergence tests for the BAS 800 01H formulation, exhibited adverse effects following exposure to the saflufenacil formulations. Comparison of the most sensitive EC_{25} values for the two formulated products show similar levels of sensitivity, within a factor of 2 to 4 for both monocots and dicots. Seedling emergence testing with the M07 and M08 degradates shows that the degradates are less toxic to plants than the tested saflufenacil formulations. No effect greater than 25% was observed in the degradate seedling emergence tests, with the exception of onion, in both M07 and M08 tests, and tomato in the M08 test.

1.5. Uncertainties and Data Gaps

Given that saflufenacil is classified as an LDPH, there are uncertainties associated with the potential for enhanced toxicity of this chemical in the presence of UV light, which has been demonstrated for other LDPH chemicals such as oxyfluorfen. The current suite of guideline toxicity tests considered in this assessment were conducted under normal laboratory lighting conditions; therefore, the extent to which toxicity may be enhanced in the presence of natural sunlight is uncertain. The Agency has been working with the LDPH Task Force, of which the registrant for saflufenacil (BASF) is a member, to develop a protocol for a freshwater early life stage (ELS) study intended to evaluate the potential effect of UV light on the toxicity of surrogate LDPH chemicals. Based on the results of the modified light study for the surrogate chemicals, an appropriate toxicity adjustment facot will be derived for application to the remaining chemicals in the class of herbicides. However, the protocol has not yet been finalized, and no phototoxicity data are available for saflufenacil. In the absence of data to determine an appropriate adjustment factor for LDPH chemicals, an interim enhanced toxicity adjustment factor of 29x has been established by EFED's Aquatic Biology Technical Team (ABTT), based on available modified light and standard light ELS fish data for oxyfluorfen (USEPA, 2009c). As stated in the ABTT memo (USEPA, 2009c), the interim toxicity adjustment factor of 29x is applicable only to chronic fish data because, in general, the extent to which UV light enhances the toxicity of saflufenacil to other taxa (*i.e.*, aquatic invertebrates, birds, and mammals) or other life stages (*i.e.*, juveniles and adults) is unknown. It is important to note, however, that the available data for saflufenacil indicate sublethal effects for mammals, such as hematological toxicity (anemia), which are consistent with the LDPH mode of action. Therefore, it appears that other taxa may be affected, although it unclear whether these effects may be exacerbated under conditions of natural sunlight. Conversely, the extent to which compensatory mechanisms may offset the potential phototoxic effects in the wild are also uncertain.

As a result of the new CFR 40 Part 158 data requirements (dated July 1, 2008; 72 FR 60957 dated October 26, 2007), avian acute oral data are now required for one passerine species in addition to either a waterfowl or upland game species for all new federal actions including Section 3 New Chemical Registrations. Acceptable avian oral toxicity data were not submitted for a passerine species exposed to saflufenacil; however, the available acute oral toxicity data for mallard duck and bobwhite quail, when compared to estimated environmental concentrations of saflufenacil, indicate that LOCs are not exceeded for birds on an acute basis. Given that no mortality was observed at the highest treatment level in either submitted acute oral study for mallard duck or bobwhite quail, it is unclear how much more sensitive passerine species would have to be, as compared with waterfowl and upland game species, to exceed LOCs. However, the LD_{50} for passerine species would have to be at least 1.4x lower than the highest treatment level tested for waterfowl and upland game species to exceed the acute avian listed species LOC. Submittal of a protocol and subsequent data for the acute oral passerine toxicity study in accordance with OPPTS 850.2100 would reduce the uncertainty associated with risks to passerines.

Risks to terrestrial invertebrates are considered to be low based on exposure to saflufenacil and all of its formulated products with the exception of BAS 781 02 H. Non-guideline studies on the BAS 781 02H formulation show that 50% mortality to the parasitic wasp and predatory mite occur at exposures that are approximately 9 to 134 times less than the maximum application rate for the BAS 781 02H formulation of 0.134 lbs a.i./A. Given that terrestrial invertebrates toxicity data are not available for the dimethenamid-p active ingredient in the BAS 781 02H formulation, and no other guideline studies on honey bees are available for the BAS 781 02H formulation, it is unclear whether the dimethenamid-p active ingredient contributes to the toxicity of the formulated product to terrestrial invertebrates, including pollinators. Submittal of a honeybee acute contact toxicity study for the BAS 781 02H formulation, completed in accordance with OPPTS 850.3020 would reduce the uncertainty associated with the observed toxicity of this formulation to sensitive arthropod species.

2. Problem Formulation

The purpose of problem formulation is to provide the foundation for the environmental fate and ecological risk assessment for the registration of the new chemical saflufenacil (also known as BAS 800 H; N'-{2-chloro-4-fluoro-5-[1,2,3,6-tetrahydro-3-methyl-2,6-dioxo-4-(trifluoromethyl)pyrimidin-1-yl]benzoyl}-N-isopropyl-N-methylsulfamide; CAS 372137-35-4). The problem formulation sets the objectives for the risk assessment, evaluates the nature of the problem, and provides a plan for analyzing the data and characterizing the risk associated with the proposed use of saflufenacil (USEPA, 1998a).

2.1. Nature of Regulatory Action

As a new herbicide being proposed for use in the United States, the U.S. Environmental Protection Agency (EPA or the Agency) is required under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to ensure that saflufenacil does not have the potential to cause unreasonable adverse effects to the environment. In addition to non-target animals and plants, potential effects to listed species (*i.e.*, species on the Federal list of endangered and threatened wildlife and plants) are also considered under the Endangered Species Act (ESA) in order to ensure that the registration of saflufenacil is not likely to jeopardize the continued existence of such listed species or adversely modify their critical habitat. In order to meet the requirements of FIFRA and the ESA, this assessment follows EPA guidance on conducting ecological risk assessments (USEPA, 1998a) and Office of Pesticide Program's Overview Document, which contains guidance for assessing pesticide risks to non-target and listed organisms (USEPA, 2004).

The end result of the EPA pesticide registration process (*i.e.*, the FIFRA regulatory action) is an approved product label. The label is a legal document that stipulates how and where a given pesticide may be used. Product labels (also known as end-use labels) describe the formulation type (*e.g.*, liquid or granular), acceptable methods of application, approved use sites, and any restrictions on how applications may be conducted. Therefore, the use, or potential use, described by the pesticide's labels is considered "the action" being assessed. This assessment was prepared to support the new chemical registration of saflufenacil.

2.2. Stressor Source and Distribution

2.2.1. Nature of Chemical Stressor

Saflufenacil, a uracil herbicide, is a new chemical that is undergoing registration (as the technical grade active ingredient, BAS 800 H, and in five end-use products) by the registrant, BASF Corporation. It has been developed for control of broadleaf weed species in field and row crops, orchards, vineyards, and in non-agricultural areas. The five saflufenacil end-use products being proposed for registration in the United States include the following:

1. BAS 800 04H: 29.74% saflufenacil; used on legume vegetables, corn, cotton, small grains, sorghum, fallow, and sunflower

2. BAS 804 00H: 17.8% saflufenacil and 50.2% imazethapyr; used on legume vegetables (with geographic restrictions), Clearfield®corn, and soybeans
3. BAS 781 02H: 6.24% saflufenacil and 55.04% dimethenamid-p; used on corn and sorghum
4. BAS 800 01H: 70% saflufenacil; used on citrus fruit, pome fruit, stone fruit, tree nuts, and grape vines
5. BAS 800 02H: 12.27% saflufenacil; used on Christmas tree plantations, conifer and hardwood plantations, and non-agricultural areas

All of the saflufenacil end-use products are applied as broadcast spray applications to either foliar surfaces or bare ground. With the exception of BAS 800 01H, which may be applied only by ground methods, all other end-use products may be applied via ground or aerial application.

Saflufenacil belongs to a class of herbicides referred to as light-dependent peroxidizing herbicides (LDPHs), which have enhanced toxicity in the presence of solar UV light. LDPHs target a specific enzyme, protoporphyrinogen oxidase (PPO), which is present in the heme and chlorophyll biosynthetic pathways of animals and plants, respectively. Inhibition of PPO in animals and plants leads to an accumulation of phototoxic heme and chlorophyll precursors called protoporphyrins, which, in the presence of ultraviolet light, produce activated oxygen radicals that can rapidly disrupt cellular function. Some chemicals in this class have also been associated with peroxisome proliferation, which can induce hepatocellular carcinomas in rodents. (Smith and Elcombe 1989, Ashby *et al.* as cited in Krijt *et al.* 1999). Other example registered herbicides in this group include oxyfluorfen, acifluorfen, lactofen, nitrofen, and fomesafen.

The major degradates of saflufenacil (constituting greater than 10% of applied residues from environmental fate studies) include M01, M02, M04, M07, M08, M15, M22, M26, M29, M31, M33, TFP, 'product 8', and an unidentified photodegradate, 'unknown 3/2/2' (chemical names and structures are provided in **Appendix A**). Available toxicity data for the M07 degradate show no adverse effects to estuarine/marine invertebrates and aquatic vascular and non-vascular plants and minimal effects to terrestrial plants. The M08 degradate is approximately 140 to 600 times less toxic to aquatic plants as compared to parent saflufenacil, and approximately 30 to 130 times less toxic to terrestrial plants in seedling emergence tests as compared to the BAS 800 01H and BAS 800 02H formulations. M07 and M08 have the same structural backbone as the parent; however, in the case of M07, the parent's uracil ring is cleaved and, in the case of M08, the uracil ring has been saturated. The uracil ring of the parent compound is expected to be involved in the mechanism of action for phytotoxicity.

The only major degradates of saflufenacil that retain a non-cleaved and unsaturated uracil ring are the soil-associated degradates M01, M02, and product 8. However, toxicity data are not available for these degradates. Because 1) inclusion of M01, M02, and product 8 in exposure modeling would not appreciably increase exposure estimates, 2) M07 and especially M08 are structurally similar to the parent and much less toxic than the parent to aquatic and terrestrial plants and aquatic animals, and 3) remaining major degradates are equally or less structurally similar to the parent compound as M07 and M08, all degradates of saflufenacil are assumed in this assessment to be much less toxic than the parent to plants and aquatic animals. Therefore, the residues of concern for aquatic and terrestrial organisms in this assessment include saflufenacil parent alone.

2.2.2. Overview of Pesticide Usage

Five end-use formulations of saflufenacil are proposed for registration in the United States, BAS 800 04H, BAS 804 00H, BAS 781 02H, BAS 800 01H, and BAS 800 02H The proposed maximum single and annual application rate for saflufenacil is the same, at 0.356 lbs a.i./A on non-agricultural areas (BAS 800 02H). BAS 800 04H and BAS 800 01H have a proposed maximum annual application rate of 0.134 lbs a.i./A for selected agricultural crop, orchard, and fallow land uses. The end-use formulations with multiple active ingredients, *i.e.*, BAS 804 00H and BAS 781 02H, have lower proposed maximum annual application rates for labeled uses, but include directions not to exceed an annual rate of 0.134 lbs saflufenacil per acre from all sources of the chemical. Usage data are not available for saflufenacil because it is a new active ingredient proposed for use in the United States, Canada, and Australia.

2.3. Receptors

2.3.1. Aquatic and Terrestrial Effects

Table 2.1 provides examples of taxonomic groups and the surrogate species tested to evaluate the potential ecological effects of pesticides to these non-target taxonomic groups. Within each of these very broad taxonomic groups, a measure of effect from either acute or chronic exposure is selected from the available test data. Toxicological data generated from surrogate test species, which are intended to be representative of broad taxonomic groups, are used to extrapolate potential effects on a variety of species (receptors) included under these taxonomic groupings.

Table 2.1. Taxonomic Groups and Test Species Evaluated for Assessing Potential Ecological Effects of Saflufenacil.

Taxonomic Group	Example(s) of Surrogate Species
Birds[1]	Mallard duck (*Anas platyrhynchos*) Bobwhite quail (*Colinus virginianus*)
Mammals	Wistar rat (*Ratus norvegicus*)
Insects	Honey bee (*Apis mellifera L.*)
Freshwater fish[2]	Bluegill sunfish (*Lepomis macrochirus*) Rainbow trout (*Oncorhynchus mykiss*) Fathead minnow (*Pimephales promelas*)
Freshwater invertebrates	Water flea (*Daphnia magna*) Midge (*Chironomus riparius*)
Estuarine/marine fish	Sheepshead minnow (*Cyprinodon variegatus*)
Estuarine/marine invertebrates	Mysid (*Americamysis bahia*) Eastern oyster (*Crassostrea virginica*)
Terrestrial plants[3]	Monocots – corn (*Zea mays*) Dicots – soybean (*Glycine max*)
Aquatic plants and algae	Duckweed (*Lemna gibba*) Freshwater algae (*Pseudokirchneriella subcapita*)

[1] Birds represent surrogates for terrestrial-phase amphibians and reptiles.
[2] Freshwater fish may be surrogates for aquatic-phase amphibians.
[3] Four species of two families of monocots, of which one is corn; six species of at least four dicot families, of which one is soybeans.

2.3.2. Ecosystems Potentially at Risk

The ecosystems at risk are often extensive in scope; therefore, it may not be possible to identify specific ecosystems at the screening level. In general terms, terrestrial ecosystems potentially at risk could include the treated site and areas immediately adjacent to the treated site that may receive drift or runoff. These areas could include the site itself, other cultivated fields, fencerows and hedgerows, meadows, fallow fields or grasslands, woodlands, riparian habitats, and other uncultivated areas.

Aquatic ecosystems potentially at risk include water bodies adjacent to, or down stream from, the treated area and might include impounded water bodies (lentic environments) such as ponds, lakes and reservoirs, or flowing waterways (lotic environments) such as streams or rivers. For uses in coastal areas, aquatic habitat also includes marine ecosystems, including estuaries.

2.4. Assessment Endpoints

Assessment endpoints represent the actual environmental value that is to be protected, defined by an ecological entity (species, community, or other entity) and its attribute or characteristics (USEPA, 1998a). For saflufenacil, the ecological entities include the following: birds, amphibians, reptiles, mammals, freshwater fish and invertebrates, estuarine/marine fish and invertebrates, terrestrial plants, insects, and aquatic vascular and non-vascular plants. The attributes for each of these entities may include growth, survival, and reproduction. (See **Table 2.2** in **Section 2.6.2**, the Analysis Plan, for further discussion).

2.5. Conceptual Model

For a pesticide to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, and a feasible route of exposure.

The conceptual model is intended to provide a written description and visual representation of the predicted relationships between saflufenacil, potential routes of exposure, and the predicted effects for the assessment endpoints. The conceptual model consists of two major components: risk hypotheses and a conceptual diagram (USEPA, 1998a).

2.5.1. Risk Hypotheses

For saflufenacil, the following ecological risk hypothesis is being employed for this baseline-level risk assessment:

Based on the application methods, mode of action, and the sensitivity of non-target aquatic and terrestrial species (especially plants), the proposed agricultural and non-

agricultural uses of saflufenacil have the potential to reduce survival, reproduction, and/or growth in terrestrial and aquatic animals and plants via both direct and indirect adverse effects.

2.5.2. Conceptual Diagram

Application methods for saflufenacil include foliar or bare ground broadcast applications via ground, aerial, and chemigation. Ecological receptors that may potentially be exposed to saflufenacil include terrestrial and semi-aquatic wildlife (*i.e.*, mammals, birds, terrestrial-phase amphibians, terrestrial invertebrates, and reptiles) and plants. In addition, aquatic receptors, (*i.e.*, freshwater and estuarine/marine fish and invertebrates, aquatic-phase amphibians, and plants) may also be exposed as a result of potential movement of saflufenacil to aquatic environments via spray drift, runoff, and/or base flow from ground water leachate originating at the site of application. The potential exposure pathways and effects of the proposed new registration of saflufenacil are depicted in **Figure 2.1**.

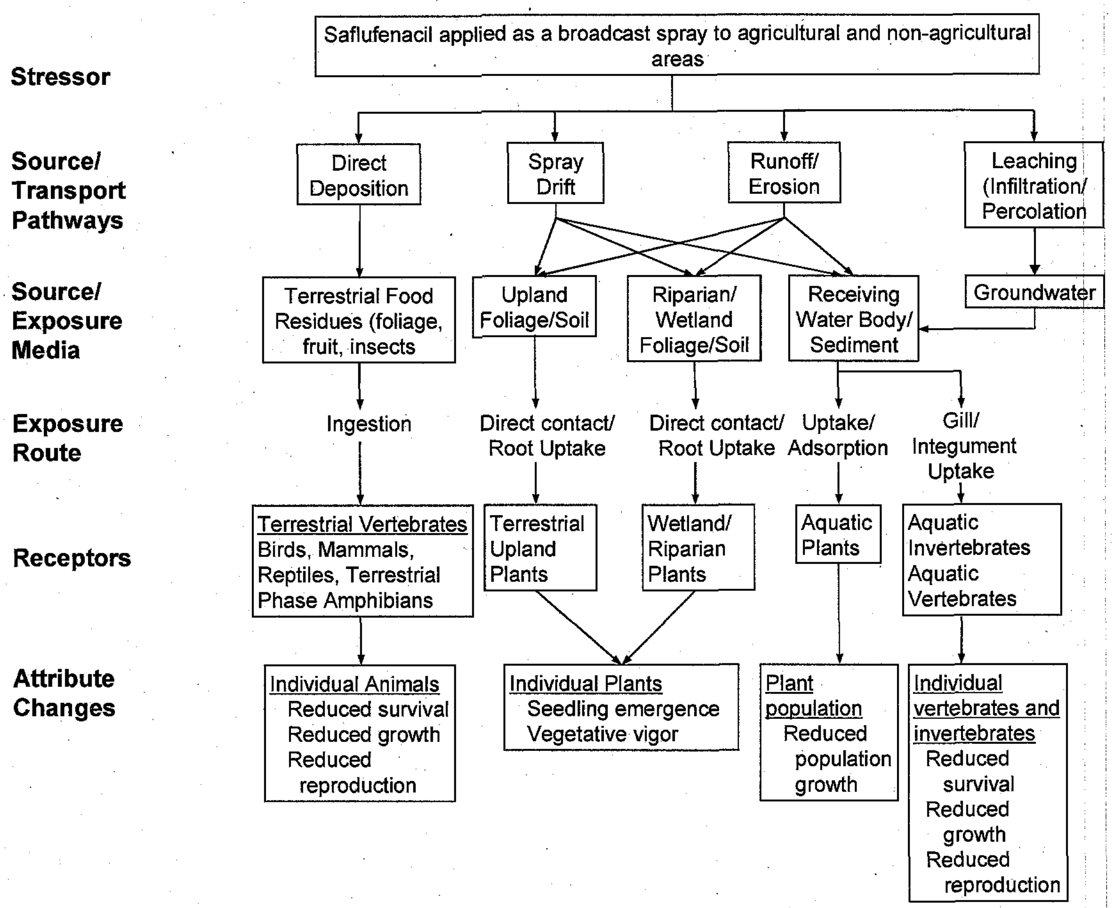

Figure 2.1. Conceptual Model Depicting Sources of Exposure, Potential Receptors, and Adverse Effects from the Proposed Uses of Saflufenacil as a Pre-plant, Pre-emergence and Post-emergence Herbicide to Control Broadleaf Plants.

2.6. Analysis Plan

2.6.1. Measures of Exposure

Measures of exposure are based on terrestrial and aquatic models that estimate environmental concentrations of the chemical being assessed using labeled application rates and methods. The measure of exposure for aquatic species in water bodies receiving runoff and/or spray drift is the estimated environmental concentration (EEC) expected once every ten years based on 30 years of simulations (estimated with PRZM/EXAMS). The 1-in-10 year peak concentration is used for estimating acute effects to aquatic vertebrate and invertebrate species; the 1-in-10 year 21-day mean concentration is used for assessing aquatic invertebrate chronic exposure; and the 1-in-10 year 60-day mean concentration is used for assessing chronic exposure for fish (and aquatic-phase amphibians). The measure of exposure for aquatic species in water bodies receiving base flow from ground water leachate originating at the site of application is the 90-day mean high concentration (estimated with SCI-GROW). The terrestrial measure of exposure for vertebrate and invertebrate animals is the upper 90th percentile concentration normalized for application rates on various dietary items (estimated with T-REX).

Exposure for terrestrial plants inhabiting dry and semi-aquatic areas (*i.e.*, low-lying wet areas that may dry up at times throughout the year; estimated with TerrPlant) is based on the following:

(1) the pesticide's water solubility and the amount of pesticide present on the soil surface and its top one centimeter,
(2) potential "sheet runoff" (one treated acre to an adjacent acre) for dry areas,
(3) potential "channel runoff" (10 acres to a distant low-lying acre) for semi-aquatic or wetland areas,
(4) fractional runoff values of 0.01, 0.02, and 0.05 for pesticide water solubilities of <10, 10-100, and <100 ppm, respectively, and
(5) an assumption of 1% spray drift for ground application and 5% for aerial, airblast, forced air, and spray chemigation applications.

The registrant has provided a suite of studies pertinent to most Subdivision N guidelines, which provides environmental fate data for these measures of exposure.

2.6.2. Measures of Effect

Measures of effect are obtained from a suite of registrant-submitted guideline studies that were conducted with a limited number of surrogate test species **(Table 2.1)**. No additional ecotoxicity data on saflufenacil were located, based on a March 2009 query of the open literature in the ECOTOX database (USEPA, 2009b).

The acute measures of effect used in this baseline-level assessment are the LD_{50} (median Lethal Dose), LC_{50} (median Lethal Concentration) or EC_{50} (median Effects Concentration). These are measures of acute toxicity which result in 50% of the respective effect in tested organisms. The endpoints for chronic measures of exposure are the NOAEC and the NOAEL. Toxicity studies were submitted for freshwater fish and invertebrates, estuarine/marine fish and invertebrates, aquatic plants, birds, mammals, bees, and other terrestrial invertebrates. The endpoints used for risk characterization were derived from studies which underwent review and were classified as "acceptable" (conducted under guideline conditions and considered to be scientifically valid) or "supplemental" (conditions deviated from guidelines but the results are considered to be scientifically valid).

Table 2.2 lists the measures of environmental exposure and ecological effects used to assess the potential risks of saflufenacil to non-target organisms. The methods used to assess the risk are consistent with those outlined in the document "Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs" (USEPA, 2004).

Table 2.2. Measures of Exposure and Effect Used in Assessing Potential Risks Associated with the Proposed Uses of Saflufenacil.

Assessment Endpoint		Measures of Ecological Effect[1]	Measures of Exposure
Birds[2]	Survival	Lowest acute LD_{50} (single oral dose test) and LC_{50} (subacute dietary test)	Upper-bound residues on food items
	Reproduction and Growth	Lowest NOAEC (21-week reproduction test)	
Mammals	Survival	Lowest acute LD_{50} (single oral dose test)	
	Reproduction and Growth	Lowest NOAEC (2-generation reproduction test)	
Aquatic Animals (Freshwater fish and inverts and estuarine/marine inverts)[3]	Survival	Lowest tested LC_{50} or EC_{50} (acute toxicity test)	Peak EECs[4]
	Reproduction and Growth	Lowest NOAEC (early life-stage or full life-cycle tests)	21-day EECs for invertebrates and 60-day EECs for fish[4]
Terrestrial plants[5]	Survival and growth	Lowest EC_{25} (for non-listed plants) and corresponding NOAEC or EC_{05} (for listed plants) (endpoints derived for monocots and dicots from seedling emergence and vegetative vigor studies)	Estimates of runoff and spray drift to non-target areas
Insects	Survival (not quantitatively assessed)	Lowest honeybee LD_{50} (acute contact test) and lowest non-guideline soil arthropod LR_{50}	Maximum application rate
Aquatic plants (vascular and non-vascular)	Survival and growth	Lowest EC_{25} (for non-listed plants) and corresponding NOAEC or EC_{05} (for listed plants)	Peak EECs[4]

[1] The most sensitive species tested within taxonomic groups is used for baseline-level risk assessments.
[2] Birds represent surrogates for terrestrial-phase amphibians and reptiles.
[3] Freshwater fish represent surrogates for aquatic-phase amphibians.
[4] Aquatic EECs are based on the modeling described in **Section 3.2.2.1**.
[5] Four species of two families of monocots - one is corn, six species of at least four dicot families, of which one is soybeans.

2.6.3. Integration of Exposure and Effects

The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects on non-target species. For the risk assessment of saflufenacil, the risk quotient (RQ) method is used to compare estimated exposure and measured toxicity values. The RQ method involves dividing EECs by acute and chronic toxicity values. The resulting RQs are then compared to the Agency's Levels of Concern (LOC) (USEPA, 2004) (**Table 2.3**). These criteria are used to indicate when applications of saflufenacil, as directed on the label, have the potential to cause adverse effects to listed and non-listed non-target organisms.

Table 2.3. Agency Risk Quotient (RQ) Metrics and Levels of Concern (LOC) Per Risk Class.

RISK CLASS	RISK DESCRIPTION	RQ	LOC
Aquatic Animals (fish and invertebrates)			
Acute	Potential for effects to non-listed animals from acute exposures	Peak EEC/LC_{50}[1]	0.5
Acute Restricted Use	Potential for effects to animals from acute exposures Risks may be mitigated through restricted use classification	Peak EEC/LC_{50}[1]	0.1
Acute Listed Species	Listed species may be potentially affected by acute exposures	Peak EEC/LC_{50}[1]	0.05
Chronic	Potential for effects to non-listed and listed animals from chronic exposures	60-day EEC/NOAEC (fish)	1
		21-day EEC/NOAEC (invertebrates)	
Aquatic Plants			
Non-Listed	Potential for effects to non-listed plants from exposures	Peak EEC/LC_{50}[1]	1
Listed	Potential for effects to listed plants from exposures	Peak EEC/NOAEC	1
Terrestrial Animals (mammals and birds)			
Acute	Potential for effects to non-listed animals from acute exposures	EEC[2]/LC_{50} (Dietary)	0.5
		EEC/LD_{50} (Dose)	
Acute Restricted Use	Potential for effects to animals from acute exposures Risks may be mitigated through restricted use classification	EEC[2]/LC_{50} (Dietary)	0.2
		EEC/LD_{50} (Dose)	
Acute Listed Species	Listed species may be potentially affected by acute exposures	EEC[2]/LC_{50} (Dietary)	0.1
		EEC/LD_{50} (Dose)	
Chronic	Potential for effects to non-listed and listed animals from chronic exposures	EEC [2]/NOAEC	1
Terrestrial and Semi-Aquatic Plants			
Non-Listed	Potential for effects to non-target, non-listed plants from exposures	EEC/ EC_{25}	1
Listed Plant	Potential for effects to non-target, listed plants from exposures	EEC/ NOAEC	1
		EEC/ EC_{05}	

[1] LC_{50} or EC_{50}.
[2] Based on upper bound Kenega values for foliar exposure.

3. Analysis

3.1. Use Characterization

Saflufenacil, also known as BAS 800 H, is a new contact and residual herbicide in the uracil class of compounds that is absorbed by roots and foliage, with limited systemic activity, according to the proposed end-use product label, BAS 800 04H. The compound belongs to the mode-of-action Group 14/Group E, meaning that it inhibits protoporphyrinogen-oxidase (PPO), resulting in an accumulation of protoporphyrins that, in the presence of UV light, can be photoactivated into reactive oxygen radicals that have the potential to cause oxidative damage to cell membranes. Saflufenacil is proposed for use on broadleaf weeds via pre-plant and pre-emergence applications to cereal small grains, corn, chickpeas, cotton, edible beans, edible peas, lentils, lupine, sorghum, soybeans, and sunflowers; via post-emergence applications to fruit trees, nut trees, and vineyards; and via applications to fallow croplands and non-agricultural areas, including pine plantations, rights-of-way, bare ground, and Christmas tree plantations. Saflufenacil is also proposed for use as a desiccant and/or defoliant on sunflower.

Five end-use formulations of saflufenacil are proposed for registration in the United States. These include BAS 800 04H (29.74% a.i.), an aqueous suspension concentrate (SC) for agricultural crop and fallow land uses; BAS 804 00H (17.80% a.i.), a water soluble granule (WG) containing 50.20% imazethapyr and for agricultural uses; BAS 781 02H (6.24% a.i.), an emulsifiable concentrate (EC) containing 55.04% dimethenamid-P and for agricultural uses; BAS 800 01H (70.0% a.i.), a water soluble granule (WG) for orchard and vineyard uses; and BAS 800 02H (12.27% a.i.), an emulsifiable concentrate (EC) for non-agricultural uses. **Table 3.1** lists the proposed use patterns and maximum application rates on the proposed labels for these five end-use formulations.

The proposed maximum single and annual application rate for saflufenacil is the same, at 0.356 lbs a.i./A on non-agricultural areas (BAS 800 02H), which characterizes the maximum use pattern of saflufenacil for this baseline-level assessment. BAS 800 04H and BAS 800 01H have a proposed maximum annual application rate of 0.134 lbs a.i./A for selected agricultural crop, orchard, and fallow land uses. The formulated end-use products containing multiple active ingredients, *i.e.*, BAS 804 00H and BAS 781 02H, have lower proposed maximum annual application rates for labeled uses, but include directions not to exceed an annual rate of 0.134 lbs saflufenacil per acre from all sources of the chemical.

Table 3.1. Proposed use patterns for saflufenacil end-use products.					
Product Label	**Active Ingredient (%)**	**Use**	**Maximum Single Application Rate (lbs saflufenacil/A)**	**Maximum Annual Application Rate (lbs saflufenacil/A)**	**Additional Application Directions**
BAS 800 04H (EPA file symbol 7969-ETI)	Saflufenacil (29.74%)	Fallow, post-harvest	0.13	0.13	Equipment: ground or aerial.
		Field corn[a], sweet corn[b], and popcorn Sorghum	0.13	0.13	Application timing: 14-30 days prior to planting (incorporated or surface) or pre-emergence. Application rates 15-30 days prior to planting vary by soil texture and organic matter (higher rates on finer soils and soils with higher organic matter); not so 14 days prior to planting. Equipment: ground or aerial.
		Cotton	0.045	0.045	Application timing: prior to accumulation of 1-inch of rainfall or irrigation to occur 21 days prior to planting. Equipment: ground or aerial.
		Legume vegetables[c] Soybeans (tolerant)	0.089	0.089	Application timing: pre-plant or pre-emergence (pre-plant only for lentils). Equipment: ground or aerial.
		Small grains[d]	0.13	0.13	Application timing: pre-plant or pre-emergence (dormant or during and/or after spring green up for winter wheat at 0.045 lbs a.i./A). Equipment: ground or aerial.
		Sunflower	0.045	0.089	Maximum number of applications per year: 2 (interval not stated). Application timing: at least 7 days prior to harvest (for desiccation). Equipment: ground or aerial.
BAS 804 00H (EPA file symbol 7969-EIN)	Saflufenacil (17.80%) and Imazethapyr (50.20%)	Clearfield® corn	0.023	0.023	Maximum annual app. rate from all sources: 0.134 lbs saflufenacil/A for Clearfield® corn; 0.089 lbs saflufenacil/A for legume vegetables and soybeans. Application timing: pre-plant or pre-emergence (pre-emergence only for Clearfield® corn). Equipment: ground or aerial.
		Legume vegetables (per region)[c]	0.017 (Southern peas only: 0.023)	0.017 (Southern peas only: 0.023)	
		Soybeans	0.023	0.023	
BAS 781 02H (EPA file symbol 7969-ETO)	Saflufenacil (6.24%) and Dimethenamid-P (55.04%)	Field corn[a], sweet corn[b], and popcorn Grain sorghum	0.11	0.11	Maximum annual app. rate from all sources: 0.134 lbs saflufenacil/A. Application timing: 14-30 days prior to planting (incorporated or surface) or pre-emergence. Application rates 15-30 days prior to planting vary by soil texture and organic matter (higher rates on finer soils and soils with higher organic matter); not so 14 days prior to planting. Equipment: ground, aerial, or chemigation.

Table 3.1. Proposed use patterns for saflufenacil end-use products.

Product Label	Active Ingredient (%)	Use	Maximum Single Application Rate (lbs saflufenacil/A)	Maximum Annual Application Rate (lbs saflufenacil/A)	Additional Application Directions
BAS 800 01H (EPA file symbol 7969-ETA)	Saflufenacil (70%)	Citrus fruit, pome fruit, stone fruit, tree nuts	0.045	0.13	Maximum number of applications per year: 3 (at least 21 days apart). Application timing: post-emergence. Equipment: ground.
		Grape vines	0.022	0.066	
BAS 800 02H (EPA file symbol 7969-ETT)	Saflufenacil (12.27%)	Christmas tree plantations	0.356	0.356	Application timing: post-emergence for Christmas tree plantations; pre-plant for conifer and hardwood plantations; no directions for non-agricultural areas. Equipment: ground or aerial.
		Conifer and hardwood plantations			
		Non-agricultural areas			

3.2. Exposure Characterization

3.2.1. Environmental Fate and Transport Characterization

Saflufenacil [N'-[2-chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-(trifluoromethyl)-3,6-dihydro-1(2H)-pyrimidinyl)benzoyl]-N-isopropyl-N-methylsulfamide; CAS 372137-35-4] is nonvolatile, hydrophilic, and mobile to highly mobile in soil. The solubility of the compound is pH-dependent; at environmentally relevant pH values, saflufenacil is expected to be ionic. The compound dissipates in the environment through both biotic and abiotic degradation and by leaching and is not expected to persist in aerobic soil (half-life of 1-5 weeks) or alkaline water bodies (half-life of <1 week). Saflufenacil may be moderately persistent in acidic to neutral water bodies (half-life of 4-10 weeks). Terrestrial field dissipation study results are relatively consistent with those of the laboratory studies, showing that the chemical dissipates by degradation and leaching, with dissipation half-lives ranging from 1 to 36 days. **Table 3.2** summarizes the submitted environmental fate data for saflufenacil.

Table 3.2. General chemical properties and environmental fate parameters of saflufenacil.

Parameter	Value	Source
Selected Physical/Chemical Parameters		
Molecular mass	500.86	MRID 47127817
Vapor pressure (extrapolated)	20°C: 3.4×10^{-17} torr 25°C: 1.5×10^{-16} torr	MRID 47127821
Water solubility (20°C)	pH 4: 14 mg/L pH 5: 25 mg/L pH 7: 2,100 mg/L pH 9: nd[A]	MRID 47127819
Henry's Law Constant (25°C)	4.01×10^{-20} atm-m^3/mol	MRID 47127822
pKa	4.41	MRID 47127817
Log octanol-to-water partition coefficient (log K_{OW} at pH <4.41)	2.56	MRID 47127818
Persistence		
Hydrolysis half-life (25°C)	pH 5: Stable pH 7: 248 d pH 9: 4.93 d	MRID 47127823
Aqueous photolysis half-life (22°C)	56 d (buffer; pH 5) 22 d (pond water; pH 7.1)	MRID 47699901
Soil photolysis half-life (22°C)	66 d (12-hr light/day) 84 d (continuous irradiation)	MRID 47127825
Aerobic soil metabolism half-life (25°C)	9.3 d (silt loam; pH 6.1) 23.3 d (loamy sand; pH 5.9) 26.2 d (silty clay loam; pH 5.5) 32.1 d (sandy loam; pH 6.8)	MRID 47445901
Anaerobic soil metabolism half-life (25°C)	[217 d][B] (loamy sand; pH 5.0-6.0)	MRID 47611201
Anaerobic aquatic metabolism half-life (25°C)	[29.4 d][B] (pH 5.5-8.5)	MRID 47127828

Table 3.2. General chemical properties and environmental fate parameters of saflufenacil.		
Parameter	**Value**	**Source**
Aerobic aquatic metabolism half-life (25°C)	70.7 d (dark; pH 5.8-6.7) 3.6 d (12-hr light/day; pH 6.1-8.0)	MRID 47127827
	Mobility	
Freundlich organic carbon normalized partition coefficients (K_{FOC})	9.3, 19, 22, 23, 25, and 55 L/kg_{OC}	MRID 47127829
Fish bioconcentration factors (BCF)	4.63 (whole fish; pH 7.5-7.8) 0.33 (edible tissue) 5.86 (inedible tissue)	MRID 47127909
	Field Dissipation	
Terrestrial field dissipation half-life (Soil series; texture); maximum depth of leaching — Georgia:	10.7 d (Fuquay; sandy loam); 45-60 cm	MRID 47127834
Arkansas: Illinois: Manitoba:	6.25 d (Commerce; silt loam); 7.5-15 cm 11.1 d (Cisne-Huey Complex; silt loam); 0-7.5 cm 35.5 d (Neuhorst; loam); 15-30 cm	MRID 47127835
Washington: Ontario: California:	1.4–4.6 d (Quincy; loamy sand); 5-15 cm 7.3–23.6 d (Brant; loam); 5-15 cm 13.0–32.2 d (San Joaquin; clay loam); 5-15 cm	MRID 47127836

A "nd" means not determined due to degradation.
B Half-lives are highly uncertain.

3.2.1.1. Transport and Mobility

Saflufenacil will not significantly volatilize due to a low vapor pressure (1.5×10^{-16} torr at 25°C; MRID 47127821) and a solubility in water that increases with increasing pH (14 mg/L (pH 4) to 2.1×10^{3} mg/L (pH 7) at 20°C; MRID 47127819). Saflufenacil's solubility in water could not be determined at pH 9 due to its susceptibility to hydrolysis. The range of solubility in water across pH values indicates that the compound exhibits acid/base behavior.

Saflufenacil is expected to be ionic at pH values above its pKa of 4.41 (MRID 47127817). Dissociation was not determined above pH 5.28. Given the similarity in water solubility at pH 4 (14 mg/L) and pH 5 (25 mg/L) and the substantially higher water solubility at pH 7 (2.1×10^{3} mg/L), it is uncertain whether saflufenacil has an additional dissociation constant above pH 5 and whether the water solubility value at pH 5 is accurate. Acid/base behavior with respect to octanol-to-water partitioning was not studied, as the log K_{OW} (2.56) was only determined for the neutral species at an unreported pH value less than the compound's pKa of 4.41 (MRID 47127818).

As an ionic compound at environmental pH values, saflufenacil is not expected to bioaccumulate. A fish bioconcentration study confirmed that saflufenacil will not bioconcentrate, with a maximum BCF of 5.86 for inedible tissue (MRID 47127909).

At environmental pH values (initial soil pH values of 5.5-8.0), saflufenacil weakly sorbs to soil (MRID 47127829). However, the compound displays affinity to organic matter (*e.g.*, the coefficient of variation (CV) across six soils for K_{FOC} (60%) is less than that for K_F (97%)).

According to the FAO soil mobility classification scheme, saflufenacil is mobile to highly mobile in soil (K_{FOC} of 9.3 to 55 L/kg_{OC}; USEPA, 2006). The compound may readily leach into ground water, depending on the permeability of the soil, and move into surface water through runoff and/or baseflow from ground water leachate in acidic to neutral environments.

3.2.1.2. Degradation

Saflufenacil degrades in the environment through both abiotic and biotic processes, some of which are not well understood. Hydrolysis of saflufenacil is pH-dependent, as the compound degrades readily in alkaline environments (half-life of 5 days at pH 9) and persists in acidic to neutral conditions (stable at pH 5; half-life of 248 days at pH 7; MRID 47127823). Major hydrolysis degradates include M04, M07, M15, and M33 (chemical names, structures, and maximum formed amounts of all degradates are listed in **Tables A-1 and A-2 of Appendix A**).

The compound slowly photodegrades in clear, near-surface water (half-lives of 56 days in a sterile pH 5 buffer and 22 days in unsterile pH 7.1 pond water; MRID 47699901) and on soil (half-lives of 66 days under 12 hours of irradiation per day and 84 days under continuous irradiation followed by conversion to a value reflecting 12 hours of irradiation per day; MRID 47127825). No major degradates were formed in the sterile pH 5 buffer. M29, M33, and an unidentified compound were major degradates in the pond water. Major photolysis degradates on soil included M15 under 12 hours of light per day and product 8 under continuous irradiation (product 8 degraded to M01 during handling and analysis). These degradates were not formed in major amounts in the dark, where M07 and M08 were.

In aerobic soil, saflufenacil degraded with a half-life ranging from 9.3 to 32 days in four soils (pH 5.5 to 6.8; MRID 47445901). The major degradates were M01, M02, M07, M08, M22, M26, and M31, which were up to 10%, 31%, 52%, 66%, 16%, 18%, and 18% of the applied, respectively. M02, M08, and M22 were major degradates in all four soils. M26 was a major degradate in only the silt loam soil, in which saflufenacil degraded the quickest. A mixture of volatile compounds (M26, M29, and carbon dioxide) also accounted for up to 16.5% of the applied radioactivity in the silt loam test system; however, their individual proportions were not determined. It is unusual that the most prominent degradate (M08) in this aerobic study was a reduction product. Its presence is likely the result of enzymatic (*i.e.*, uracil hydrogenase) activity.

In anaerobic soil, saflufenacil was relatively persistent (half-life of 217 days) in one soil (pH 5.0-6.0; MRID 47611201). Major degradates included M01, M02, and M08, which were a maximum of 14%, 24%, and 25% of the applied, respectively. Results of the study are highly uncertain because anaerobic conditions were marginal; the mean redox potential (Eh) in the post-flood water was -34 ± 88 mV (n=28). OECD Guideline 308 states that anaerobic sediment and water are regarded as anaerobic once the redox potential is lower than –100 mV. However, the degradate profile indicates that anaerobic conditions were present, even if they were not fully maintained.

In anaerobic aquatic systems, saflufenacil degraded with a half-life of 29.4 days in one system (pH 5.5-8.5). Major degradates included M07, M15, M29, M33, and 1,1,1-trifluoro-2-propanol (TFP), which were a maximum of 71%, 16%, 11%, 16%, and 19% of the applied, respectively, in the total system. Results of the study are highly uncertain because anaerobic conditions in the water layer, where the majority of the applied compound partitioned, were marginal; redox potential was not measured in the water layer (it was reducing to strongly reducing in the sediment layer) and dissolved oxygen in the water layer was up to 1.7 mg/L. Additional uncertainty was due to a declining material balance for the uracil-labeled system and significant dissipation (35-50% of the applied) of saflufenacil in both systems between the 30- and 62-day sampling intervals, when dissolved oxygen appeared to be most elevated. Due to the detection of major and minor degradation products in this study that were not detected in the aerobic aquatic metabolism or hydrolysis studies, it appears that conditions were partially anaerobic.

In aerobic aquatic systems, saflufenacil degraded with a half-life of 70.7 days at pH 5.8-6.7 (MRID 47127827). The major transformation products were M07, M29, M33, and carbon dioxide, which were a maximum of 23%, 8.8%, 23%, and 11% of the applied, respectively, in the total system. Results of the study are uncertain because dissolved oxygen concentrations (2.7-5.5 mg/L, corresponding to ~33-65% saturation at 25°C) were less than the typical range (7-10 mg/L, corresponding to ~84-100% saturation at 25°C) and recoveries of the uracil-labeled systems were highly variable (76% to 114%). Regardless, redox potentials in the water layer (ranging +150 to +410 mV) indicate that the test system was aerobic. It is not clear why saflufenacil appears to degrade with shorter half-lives in aerobic terrestrial and anaerobic aquatic systems (9.3 to 32 days) than in anaerobic terrestrial and aerobic aquatic systems (half-lives of 71 to 217 days).

3.2.1.3. Field Studies

Three terrestrial field dissipation studies were conducted for saflufenacil using five sites in the United States and two sites in Canada, each with three bare ground plots that had <1% slope and no runoff collection equipment. The study results are relatively consistent with those of the laboratory studies, showing that the chemical dissipates by degradation and leaching, with dissipation half-lives ranging from 1 to 36 days.

One study was conducted on a sandy loam soil (Fuquay soil series) in Georgia (MRID 47128234). Saflufenacil was broadcast once at a target application rate of 0.40 kg a.i./ha (0.357 lb a.i./A), which is the proposed maximum application rate (for use on tree plantations and non-agricultural areas). Total water input was 122% of the historical average. Soil samples (0-120 cm depth) were collected through 451 days after treatment. The mean zero-time concentration of saflufenacil in the 0-7.5 cm soil depth was 0.19 ppm, which was 57% of the theoretical zero-time concentration. Saflufenacil dissipated in the whole soil profile with a half-life of 11 days. The compound was detected above the limit of quantitation (LOQ = 0.01 ppm or 3% of the theoretical zero-time concentration) at a maximum depth of 45-60 cm, 32 days after treatment, which indicates a potential to leach.

For each study, test sites were analyzed for M01, M02, M07, M08, M15, and M22. The limit limit of quantitation (LOQ) for each degradate was 0.01 ppm (detections between the limit of detection (LOD) and the LOQ were not reported). In each study, substantial degradate concentrations may have been present at less than 0.01 ppm. Therefore, the analytical method may have been too insensitive to accurately describe the leaching potential of these degradates.

In the Georgia sandy loam, M08, M01, and M02 were detected above the LOQ. M08 was detected in the 0-7.5 cm and 7.5-15 cm soil depths at maximum concentrations of 0.04 ppm on the day of treatment (21% of the initial soil concentration of saflufenacil) and 0.05 ppm at 6 days after treatment (26% of the initial soil concentration of saflufenacil), respectively, and was detected above the LOQ at a maximum depth of 90-105 cm at 46 and 75 days after treatment, which indicates a potential to leach. M01 was detected in the 0-7.5 cm soil depth at a maximum concentration of 0.02 ppm (10.8% of the initial soil concentration of saflufenacil) from 0-8 days after treatment and was not detected above the LOQ below the 7.5-15 cm depth, which indicates that M01 is less mobile than the parent compound. M02 was detected in the 0-7.5 cm soil depth at a maximum concentration of 0.01 ppm (5.4% of the initial soil concentration of saflufenacil) at 0, 1, 2, and 6 days after treatment and was not detected above the LOQ in soil below the 0-7.5 cm depth, which indicates that M02 will not leach. However, the maximum detected concentrations of M01, M02, and M08 in this soil were near the LOQ. Therefore, the analytical method would have been insensitive to residues leaching at similar concentrations less than 0.01 ppm.

A second study was conducted on silt loam soils in Arkansas (Commerce soil series) and Illinois (Cisne-Huey Complex soil series) and on a loam soil (Neuhorst soil series) in Manitoba (MRID 47128235). Saflufenacil was broadcast once at a target application rate of 0.15 kg a.i./ha (0.134 lb a.i./A), which is the proposed maximum application rate for use on corn, sorghum, small grain crops, and fallow land. Total water input at these sites was 97% to 108% of the historical average. Soil samples (0-120 cm depth) were collected through 360 days after treatment. The mean zero-time concentrations of saflufenacil in the 0-7.5 cm soil depth of each site were 0.16 ppm, 0.14 ppm, and 0.09 ppm, which were 101%, 107%, and 48% of the theoretical, respectively. Saflufenacil dissipated in the whole soil profile of each site with respective half-lives of 6.25, 11.1, and 35.5 days. The compound was detected above the limit of quantitation (LOQ = 0.01 ppm or 5.3% to 7.6% of the theoretical zero-time concentration) at a maximum depth of 7.5-15 cm in the Arkansas silt loam soil (2 and 6-8 days after treatment), a maximum depth of 0-7.5 cm in the Illinois silt loam soil (0-45 days after treatment), and a maximum depth of 15-30 cm in the Manitoba loam soil (6 days after treatment). The maximum soil depths at which saflufenacil was detected and the intervals at which these detections occurred in the Arkansas silt loam and Manitoba loam soils indicate a potential to leach.

In the Arkansas silt loam, M08 was the only degradate detected above the LOQ. In the 0-7.5 cm soil depth, M08 was detected at a maximum concentration of 0.03 ppm (19% of the initial soil concentration of saflufenacil) at 75 to 90 days after treatment and was not detected above the LOQ below this depth. In the Illinois silt loam, M08 was the only degradate detected above the LOQ. In the 0-7.5 cm soil depth, M08 was detected at a maximum concentration of 0.03 ppm (21% of the initial soil concentration of saflufenacil) at 30 to 45 days after treatment and was not detected above the LOQ below the 7.5-15 cm depth. In the Manitoba loam, M07 and M08 were detected above the LOQ. In the 0-7.5 cm soil depth, M08 was detected at a maximum concentration of 0.03 ppm (33% of the initial soil concentration of saflufenacil) at 6 days after treatment and was not detected above the LOQ below this depth. M07 was detected in the 0-7.5 cm soil depth at a concentration of 0.01 ppm (15% of the initial soil concentration of saflufenacil) at 45 days after treatment and was not detected above the LOQ below this depth. The detections of M07 and M08 in these soils are not indicative of leaching. However, the maximum detected concentrations were near the LOQ. Therefore, the analytical method would have been insensitive to residues leaching at similar concentrations less than 0.01 ppm.

The third study was conducted on a loamy sand soil (Quincy soil series) in Washington, a loam soil (Brant soil series) in Ontario, and a clay loam soil (San Joaquin soil series) in California (MRID 47128236). Saflufenacil was broadcast three times (21- to 23-day interval) at each site at a target application rate of 0.05 kg a.i./ha/application (0.045 lb a.i./A/application), which is the proposed maximum application pattern for use on orchard trees. Total water input at these sites was 131% to 846% of the historical average. Soil samples (0-120 cm depth) were collected from each site through 20 days after the first treatment, 20 days after the second treatment, and 360 days after the third. Following the first application, the mean zero-time concentrations of saflufenacil in the 0-2.5 cm soil depth of each site were 0.09 ppm, 0.10 ppm, and 0.08 ppm, which were 64%, 76%, and 50% of the theoretical, respectively. Saflufenacil dissipated in the whole soil profile, following the first and third applications, with respective half-lives of 4.6 and 1.4 days in the Washington loamy sand, 7.3 and 23.6 days in the Ontario loam, and 13.0 and 32.3 days in the California clay loam. The compound was detected above the limit of quantitation (LOQ = 0.01 ppm or 6.3% to 7.6% of the theoretical zero-time concentration) at a maximum depth of 5-15 cm in all three soils (2-10 days after the first treatment and up to 76 days after the third treatment). However, samples were not analyzed to a sufficient depth to define leaching at the Ontario site. At 2, 5, and 9 days following the first application, samples were not analyzed below 15 cm despite the detection of saflufenacil in the 5-15 cm depth at these sampling intervals. Samples were analyzed to a depth of 30-45 cm at all other sampling intervals, with no detection of saflufenacil above the LOQ at that depth on any sampling interval. Acknowledging the uncertainty in the results in the Ontario loam, these results indicate a moderate potential to leach.

In the Washington loamy sand, M08 was the only degradate detected above the LOQ. In the 0-2.5 cm soil depth, M08 was detected at a maximum concentration of 0.02 ppm following the all three applications and was not detected above the LOQ below the 2.5-5 cm depth. In the Ontario loam, M08 and M01 were detected above the LOQ. In the 0-2.5 cm soil depth, M08 was detected at a maximum concentration of 0.05 ppm at 1 day after the third application and was not detected above the LOQ below the 5-15 cm depth. In the 0-2.5 cm soil depth, M01 was detected at a maximum concentration of 0.02 ppm at 10 days after the third application and was not detected above the LOQ below this depth. In the California clay loam, M01, M07, and M08 were detected above the LOQ. In the 0-2.5 cm soil depth, M01 was detected at a maximum concentration of 0.02 ppm at 20 days after the third treatment, and M07 and M08 were detected at maximum concentrations of 0.02 ppm and 0.01 ppm, respectively, at 20 and 45 days after the third treatment. M01, M07, and M08 were not detected above the LOQ below this depth. The detections of M01, M07 and M08 in these soils are generally not indicative of leaching. However, the maximum detected concentrations were near the LOQ. Therefore, the analytical method would have been insensitive to residues leaching at similar concentrations less than 0.01 ppm.

3.2.1.4. Environmental Degradates

Fourteen major environmental degradates of saflufenacil were identified in submitted studies: M01, M02, M04, M07, M08, M15, M22, M26, M29, M31, M33, TFP, 'product 8', and an unidentified photodegradate, 'unknown 3/2/2'. Available IUPAC names and chemical structures are listed in **Table A-1 of Appendix A** as well as maximum and final amounts formed in the submitted studies. All major degradates other than M04, product 8, and unknown 3/2/2 were greater than 10% of the applied in at least one biotic degradation study (the others were abiotic degradates). M07, M15, M29, and M33 were major degradates in both biotic and abiotic degradation studies. **Table A-2 of Appendix A** lists the eleven minor degradates of saflufenacil that were also identified.

Degradates M01, M02, M08, and product 8 have an intact uracil ring and are most similar to the parent compound. M01 and M02 were major demethylation products in the aerobic and anaerobic soil metabolism studies. Product 8 was a major photodegradate on soil that was increasing in concentration at the end of the study but degraded to M01 during handling and analysis. Reduction/saturation of the uracil ring of saflufenacil produced M08, which was a major degradate in the aerobic soil metabolism and soil photolysis studies.

Degradates M04, M07, M15, and M22 have a cleaved uracil ring, but remain structurally similar to the parent compound. M04 was a major hydrolytic product at pH 9 but was not detected 18 days after its peak concentration, which indicates that it readily undergoes further degradation. M07 was a major degradate in every submitted environmental fate laboratory study with the exception of the anaerobic soil metabolism study. M15 was a major hydrolytic degradate at pH 9 and a major degradate in the anaerobic aquatic metabolism study. M22 was a major degradate in the aerobic soil metabolism study.

Degradates M26, M29, M31, M33, and TFP are trifluorinated cleavage products of the uracil ring that were identified in submitted studies. M29 is trifluoroacetic acid (CAS 76-05-1), a degradation product shared by pesticides (*e.g.*, benfluralin, trifloxystrobin, fluometuron, and thiafluamide/flufenacet), hydrochlorofluorocarbons (HCFC), and hydrofluorocarbons (HFC). According to the Hazardous Substances Data Bank, with a vapor pressure of 110 torr at 25°C, trifluoroacetic acid will volatilize if released to the air or dry soil (USNIH, 2009). Its half-life in air is estimated at 31 days due to reaction with hydroxyl radicals. However, if released to water bodies or wet soil, trifluoroacetic acid will form a persistent anion (pKa of 0.52) that will not degrade by abiotic or microbial means. The compound has been detected in surface water, seawater, and precipitation (USNIH, 2009). Therefore, there is an exposure concern of water bodies persistently contaminated with trifluoroacetic acid from sources including degrading saflufenacil residues in water bodies.

The available aquatic toxicity data for trifluoroacetic acid show low toxicity for fish and *Daphnia* (LC/EC_{50} >1200 mg/l) and a range of algal species (NOEC values are above 100 mg/L, with one exception (*Scenedesmus capricornutum*) at 0.12 mg/L; Europian Union, 2001). Also, continuous exposure (>5 months) to trifluoroacetic acid at 31-32 mg/L may cause adaptation in the physiology of stream bacterial communities (Europian Union, 2001). Based on these data, there is low aquatic toxicity concern for trifluoroacetic acid and, therefore, risk concern is presumed low. Thus, the ecological risk from trifluoroacetic acid is not quantitatively estimated in this assessment.

Fluoroform (trifluoromethane; CAS 75-46-7) is a possible terminal product of the trifluorinated degradates of saflufenacil. Visscher *et al.* (1994) found that limited amounts of trifluoroacetic acid may decarboxylate to fluoroform in some oxic sediments. According to the Hazardous Substances Data Bank, fluoroform will volatilize from water and soil based on a Henry's Law constant of 0.095 atm-m^3/mol and a vapour pressure of 3.5 x 10^4 torr at 25°C (USNIH, 2009). However, the compound has been detected in surface water and ground water. It will persist in air with a half-life of 180 years and gradually diffuse into the stratosphere with a half-life of 20 years (USNIH, 2009). As an HFC, fluoroform is included with the greenhouse gases subject to the Kyoto Protocol (United Nations, 1998). In conclusion, there is concern regarding the potential degradation of saflufenacil residues to fluoroform. However, saflufenacil residues are not expected to form substantial quantities of fluoroform. Therefore, the concern is low.

3.2.2. Measures of Aquatic Exposure

3.2.2.1. Surface Water Exposure

The Tier II model Pesticide Root Zone Model (PRZM v3.12.2; May 12, 2005; Carousel *et al.*, undated) linked with EXposure Analysis Modeling System (EXAMS v2.98.4.6; Apr. 25, 2005; Burns, 2004) via the PRZM/EXAMS model shell (PE v5.0, Nov. 15, 2006), *i.e.*, PRZM/EXAMS) was run to estimate baseline-level exposure of aquatic environments to saflufenacil. The PRZM model simulates pesticide movement and transformation on and across the agricultural field resulting from crop applications. The EXAMS model simulates pesticide loading via runoff, erosion, and spray drift assuming a "standard" 1-ha pond, 2-m deep (20,000 m^3) with no outlet that borders a 10-ha treated field. Simulations are run for multiple (usually 30) years; and the Agency estimates peak values that are expected once every ten years based on the daily values generated during the simulation. The coupled PRZM/EXAMS model and users manuals are available from the U.S. Environmental Protection Agency Water Models web-page (USEPA, 2009a).

Exposure estimates generated using this "standard" pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and first-order streams. As a group, there are factors that make these water bodies more or less vulnerable than the standard surrogate pond. Static water bodies that have larger ratios of pesticide-treated drainage area to water body volume would be expected to have higher peak EECs than the standard pond. These water bodies will be either smaller in size or have large drainage areas.

Smaller water bodies have limited storage capacity and thus may overflow and carry pesticide in the discharge, whereas the standard pond has no discharge. As watershed size increases, it becomes increasingly unlikely that the entire watershed is planted with a non-major single crop that is all treated simultaneously with the pesticide. Headwater streams can also have peak concentrations higher than the standard pond, but they likely persist for only short periods of time and are then carried and dissipated downstream.

The general chemical and environmental fate data for saflufenacil listed in **Table 3.2** were used for generating model input parameters for PRZM and EXAMS (listed in **Table 3.3**). These inputs represent the residues of concern, which include saflufenacil parent alone (see **Section 2.2.1**), and were determined in accordance with current divisional guidance (USEPA, 2002a). Since hydrolysis is not believed to have been a dominant process in submitted laboratory studies, half-lives for biodegradation and photolysis rates were not corrected for the process.

Table 3.3. PRZM and EXAMS Chemical Input Parameters for Saflufenacil.

Input Parameter	**Value**	**Comment**	**Source (MRID)**
Molecular Mass (g/mol)	501	Product chemistry data	47127817
Henry's Law Constant (atm-m^3/mol)	4.0×10^{-20}	Product chemistry data	47127822
Solubility in Water (mg/L)	2.1×10^3	Represents the value at pH 7.	47127819
Organic Carbon Partition Coefficient (K_{OC}) (L/kg$_{OC}$)	29.8	Represents the mean K_{OC} of six values.	47127829
Aerobic Soil Metabolism Half-life (days)	31	Represents the upper 90% confidence bound on the mean of four half-lives.	47445901
Aerobic Aquatic Metabolism Half-life (days)	212	Represents three times the single available half-life from dark conditions.	47127827
Anaerobic Aquatic Metabolism Half-life (days)	88	Represents three times the single available half-life.	47127828
Hydrolysis Half-life (days)	248	Represents the half-life at pH 7.	47127823
Aqueous Photolysis Half-life (days)	56	Represents the environmental phototransformation half-life from a buffered system.	47699901

The model input parameters used in PRZM to simulate saflufenacil application and crop management practices are provided in **Table 3.4**. The initial application date was selected in order to reflect labeled crop timing for applications, consistent with the crop timing set by the model scenarios and with crop-profile information provided by the United States Department of Agriculture (USDA, 2009). The maximum use pattern for non-agricultural areas was the only use pattern modeled because it produced the highest estimated aquatic exposure from all uses and resulting aquatic risk estimates were low, precluding the need for further modeling. The California rights-of-way scenario was used to model the non-agricultural use pattern because, based on a comparison of results, it was the most vulnerable of the nine available non-agricultural PRZM/EXAMS scenarios.

Table 3.4. PRZM Scenario and Input Parameters Describing the Maximum Proposed Saflufenacil Use Pattern.								
Use	Scenario	Date of Initial App.	App. Rate (lbs a.i./A)	App. per Year	App. Interval (days)	CAM Input	IPSCND Input	Application Efficiency/ Spray Drift
Non-agricultural areas[A]	CA rights-of-way	Oct. 1st	0.356	1	n/a	2	1	0.95/0.05

A Non-agricultural areas include tree plantations.

The modeled aquatic EECs resulting from the proposed saflufenacil use on non-agricultural areas (presented in **Table 3.5**) were used for risk estimation in this baseline-level assessment. The model input/output filenames supporting these values are listed in **Appendix B**.

Table 3.5. Modeled aquatic 1-in-10-year EECs for proposed saflufenacil uses (maximum values in bold).					
Uses	Scenario	Max. App. rate (lbs a.i./A/yr)	Peak (ppb)	21-day (ppb)	60-day (ppb)
Non-agricultural areas	CA rights-of-way	0.356	5.8	5.6	5.2

3.2.2.2. Ground Water Exposure

The Tier I model Screening Concentration in Ground Water (SCI-GROW v2.3, Jul. 29, 2003; USEPA, 2002b) was run to estimate screening-level exposure of aquatic environments to saflufenacil in base flow originating from ground water. SCI-GROW is a regression model that was developed by fitting a linear model to ground water concentrations with the Relative Index of Leaching Potential (RILP) as the independent variable. Ground water concentrations were taken from 90-day mean high concentrations from Prospective Ground Water studies. The RILP is a function of aerobic soil metabolism and the soil-water partition coefficient. The output of SCI-GROW represents the concentration of pesticide residue that might be expected in shallow unconfined aquifers under sandy soils, which is representative of the ground water most vulnerable to pesticide contamination and likely to result in contaminated base flow in nearby surficial water bodies. This single 90-day mean value is used to approximate both acute and chronic exposure. The SCI-GROW model and user's manual is available from the EPA Water Models web-page (USEPA, 2009a).

Input parameters for the SCI-GROW model appear in **Table 3.6**. These inputs were determined in accordance with current divisional guidance (USEPA, 2002b). The lowest reported organic carbon partition coefficient (K_{OC} = 10 L/kg$_{OC}$) and the median half-life (25 d) from four aerobic soils were selected.

Table 3.6. SCI-GROW input parameters for saflufenacil. Source data are in Tables 3.1-3.2.			
Input Parameter	**Value**	**Comments**	**Source**
Application Rate (lbs a.i./A)	0.356	Maximum proposed single application rate.	Proposed label.
Applications per Year	1	Maximum proposed number of applications per year at the maximum proposed single application rate.	Proposed label.

Table 3.6. SCI-GROW input parameters for saflufenacil. Source data are in Tables 3.1-3.2.			
Input Parameter	**Value**	**Comments**	**Source**
Organic Carbon Partition Coefficient (K_{OC}) (L/kg_{OC})	10	Represents the lowest reported K_{OC} value.	MRID 47127829
Aerobic Soil Metabolism Half-life (days)	25	Represents the median half-life in four soils.	MRID 47445901

The modeled ground water EEC resulting from saflufenacil use on non-agricultural areas was 0.36 µg/L. This value is three orders of magnitude less than estimated drinking water concentrations (EDWC) in ground water modeled in support of human health risk assessment because it represents saflufenacil parent alone, whereas EDWCs represent residues of concern in drinking water. The residues of concern in drinking water include the parent compound and seven structurally similar degradates, which have higher mobility and persistence in soil when analyzed collectively. Because the ground water EEC in this screening-level assessment is substantially less than surface water EECs and the lowest endpoint for aquatic organisms, it was not used for risk estimation. The model input/output filename and data supporting this exposure estimate is reproduced in **Appendix B**.

3.2.3. Measures of Terrestrial Exposure

The application method for the proposed saflufenacil agricultural and non-agricultural uses is limited to broadcast spray (ground, aerial, and chemigation); therefore, only broadcast applications are considered in the terrestrial exposure assessment.

3.2.3.1. Terrestrial Wildlife

Terrestrial wildlife exposure estimates are typically calculated for birds and mammals, emphasizing a dietary exposure route for uptake of pesticide active ingredients. Exposures for birds are considered as surrogates for terrestrial-phase amphibians as well as reptiles. For exposure to terrestrial organisms, such as birds and mammals, pesticide residues on food items are estimated, based on the assumption that organisms are exposed to pesticide residues in a given exposure use pattern.

The T-REX model (v1.4.1; 10/9/08) is used to calculate dietary and dose-based EECs of saflufenacil residues on food items via spray applications for mammals and birds. Input values for deriving EECs in T-REX are located in **Table 3.7**. Upper-bound Kenaga nomogram values are used to derive EECs for saflufenacil exposures to terrestrial mammals and birds. **Table 3.8** summarizes the dietary- and dose-based EECs, based on the maximum single application rate of 0.356 lbs a.i./A for non-agricultural uses. Characterization of EECs for lower application rates of saflufenacil are addressed as part of the risk characterization in **Section 4.0**. A 1-year time period is simulated. Consideration is given to different types of feeding strategies for mammals, including herbivores, insectivores and granivores. For dose-based exposures, three weight classes of birds (20, 100, and 1000 g) and three weight classes of mammals (15, 35, and 1000 g) are considered. Uncertainties in the terrestrial EECs are primarily associated with a lack of data on interception and subsequent dissipation from foliar surfaces. Given that no data on interception and subsequent dissipation from foliar surfaces are available for saflufenacil, a default foliar dissipation half-life of 35 days is used based on the work of Willis and McDowell (1987). An example output from the T-REX model is provided in **Appendix C**.

Table 3.7. T-REX Input Parameters for Deriving Terrestrial EECs for Saflufenacil Proposed Uses		
Use (Application Method)	**Application Rate (lbs a.i./A)**	**Number of Applications (Interval between applications)**
Non-agricultural areas	0.356	1
Corn, sorghum, fallow, small grains	0.134	1
Soybeans and legumes	0.089	1
Cotton	0.045	1
Sunflower	0.045	2 (3 days)
Citrus fruit, pome fruit, stone fruit, and tree nuts	0.045	3 (21 days)
Grape vines	0.022	3 (21 days)

Table 3.8. T-REX Calculated EECs of Saflufenacil Non-Agricultural Uses (0.356 lbs a.i./A) on Food Residues.							
Food Type	**Dietary Based (ppm) (mammals and birds)**	**Dose Based (mg/kg-bw) (birds)**			**Dose Based (mg/kg-bw) (mammals)**		
	All Size Classes	**Small (20 g)**	**Medium (100 g)**	**Large (1000 g)**	**Small (15 g)**	**Medium (35 g)**	**Large (1000 g)**
Short grass	85	97	55	25	81	56	13
Tall grass	39	45	25	11	37	26	6.0
Broadleaf plants/sm insects	48	55	31	14	46	32	7.3
Fruits/pods/lg insects	5.3	6.1	3.5	1.6	5.1	3.5	0.82
Seeds (granivore)	5.3	6.1	3.5	1.6	5.1	3.5	0.82

3.2.3.2. Terrestrial and Semi-Aquatic Plants

Exposure of naturally-occurring terrestrial and semi-aquatic (wetland) plant species is typically estimated using OPP's TerrPlant (v1.2.2) model and is assumed to encompass areas outside the immediate use site. The TerrPlant model is used to derive EECs for terrestrial and semi-aquatic plants near areas where saflufenacil has been applied. For non-wetland areas, exposure calculations are based on the amount of pesticide present in soil as a function of drift. Loading via drift to dry, non-target, adjacent areas is assumed to occur from one acre of treatment to one acre of the non-target area. Spray drift is also a source of pesticide loading to non-target areas. The default spray drift assumptions are 1% for ground spray applications and 5% for aerial spray and chemigation applications. TerrPlant estimates EECs based on application rate, solubility factor, and default assumptions of drift. The EECs for terrestrial and semi-aquatic plants for a single application of saflufenacil at the maximum label rate for proposed non-agricultural and agricultural uses are presented in **Table 3.9**. An example output from the TerrPlant model is provided in **Appendix D**.

Table 3.9. EECs for Terrestrial and Semi-Aquatic Plants Near Saflufenacil Use Areas.							
Use	Single Max. Application Rate (lbs a.i./A)	EECs (lbs a.i./A) (Ground Spray, Aerial Spray)					
		Total Loading to Semi-Aquatic Areas		Spray Drift		Dry Areas (Total)	
		Ground spray	Aerial spray	Ground spray	Aerial spray	Ground spray	Aerial spray
Non-agricultural areas	0.354	0.1816	0.1985	0.0036	0.0178	0.0214	0.0356
Corn, sorghum, fallow, small grains	0.134	0.0683	0.0737	0.0013	0.0067	0.0080	0.0134
Soybeans and legumes	0.089	0.0454	0.0490	0.0009	0.0045	0.0053	0.0089
Cotton, sunflower, fruits, and tree nuts[1]	0.045	0.0230	0.0248	0.0005	0.0023	0.0027	0.0045
Grape vines[2]	0.022	0.0112	NA	0.0002	NA	0.0013	NA

[1] EECs based on aerial spray apply only to cotton and sunflower use patterns; EECs based on ground spray are applicable to cotton, sunflower, fruits (including citrus, pome, and stone fruit) and tree nuts.
[2] Saflufenacil may applied to grape vines only via ground application; therefore, aerial spray EECs were not derived for this use pattern.

3.3. Ecological Effects Characterization

The ecological effects characterization is based on registrant-submitted toxicity data for saflufenacil (also referred to as BAS 800 H, technical grade active ingredient (TGAI), or technical parent product); three of its formulated products including BAS 781 02 H (6.24% saflufenacil and 55.04% dimethenamid-p), BAS 800 01H (70% saflufenacil), and BAS 800 02H (12.27% saflufenacil); and the M07 and M08 degradates. **Appendix H** lists these studies, their review classifications, and associated deficiencies. In addition, the publicly-available version of the ECOTOX database was searched on March 17, 2009 in order to provide more ecological effects data (USEPA, 2009b). The results of this query show that no additional ecotoxicity data are available for saflufenacil; therefore, all toxicity endpoints are taken from registrant-submitted studies.

A description of available aquatic and terrestrial toxicity data for saflufenacil, its formulated products, and degradates is provided in **Section 3.3.1** and **3.3.2**, respectively.

Given that saflufenacil is a new active ingredient with no previous registration in the U.S. or any other country, a query of the Agency's Office of Pesticide Programs Ecological Incident Information System (EIIS) was not completed, and it is assumed that no ecological incidents exist for saflufenacil.

3.3.1. Specific Toxicological Concerns Associated With Enhanced Toxicity of Saflufenacil in Natural Sunlight

Saflufenacil is included in a class of herbicides sometimes referred to as LDPHs that have enhanced toxicity in the presence of solar ultra-violet radiation. Because toxicity of the LDPHs is affected by the presence of UV radiation, most toxicity tests used in this assessment, which were conducted under standard laboratory lighting conditions, may underestimate the toxicity of saflufenacil to some taxa had studies been conducted under natural sunlight conditions. LDPHs target a specific enzyme, *i.e.*, protoporphyrinogen oxidase, in the heme and chlorophyll biosynthetic pathways of animals and plants, respectively. Inhibition of PPO in animals and plants leads to an accumulation of heme and chlorophyll precursors called protoporphyrins, which, in the presence of UV light can produce activated oxygen radicals that can rapidly disrupt cellular function. Therefore, there is the potential for saflufenacil to be more toxic in the presence of natural sunlight, as compared to results indicated by the current suite of guideline toxicity tests, which are conducted under normal laboratory lighting conditions and considered in this assessment.

The Agency has been working with the LDPH Task Force, of which BASF (the registrant for saflufenacil) is a member, to develop a protocol for a freshwater ELS study intended to evaluate the potential effect of UV light on the toxicity of three surrogate LDPH chemicals. Based on the results of the modified light fish ELS studies for the three surrogate chemicals, an appropriate toxicity adjustment factor will be derived for application to the remaining chemicals in this class of herbicides. However, the protocol has not yet been finalized, and no phototoxicity data are available for saflufenacil. Until this testing is completed to determine an appropriate adjustment factor for LDPH chemicals, an interim enhanced toxicity adjustment factor of 29x has been established by EFED's Aquatic Biology Technical Team (ABTT), based on available modified light and standard light ELS fish data for oxyfluorfen (USEPA, 2009c). The enhanced UV lighting ELS study on oxyfluorfen (MRID 46585104) demonstrated that fish were approximately 29 times more sensitive as compared to a similar ELS study conducted under standard laboratory lighting. In the modified light study, the larval fish hatched prematurely compared to the controls, and then died. Based on the LDPH mode of action, it is possible that disruption of the egg cell membrane caused the premature hatch via cellular oxidative damage to free radical formation. As stated in the ABTT memo (USEPA, 2009c), the interim enhanced toxicity adjustment factor of 29x is applicable only to chronic fish data, given that the extent to which UV light enhances the toxicity of saflufenacil to other taxa or other life stages is unknown. Further characterization of the available data and uncertainties associated with the interim safety factor are discussed in **Section 3.3.1.1** and in the risk description (**Section 4.2**).

Saflufenacil and other chemicals in this class have also been associated with anemia and other hematologic effects due to potential accumulation of protoporphyrins and generation of reactive free radicals following exposure to light. A discussion of the potential for blood-related effects, based on review of HED's mammalian guideline studies, is included in the terrestrial effects section.

3.3.2. Aquatic Toxicity Assessment

A summary of the most sensitive aquatic toxicity data for saflufenacil, including its formulated products, based on a current Agency review of all submitted data, is provided in **Table 3.10** and discussed further in **Sections 3.3.2.1** through **3.3.2.5**. The available acute aquatic toxicity data for the BAS 781 02H formulation, which contains 6.24% saflufenacil and 55.04% dimethenamid-p, show that it is approximately 3 to 7 times more toxic than parent saflufenacil to freshwater fish, invertebrates, and aquatic vascular and non-vascular plants. Dimethenamid-p is a chloroacetamide herbicide that enters plants through emerging shoots and reduces cell division and growth (PC Code 120051). All available aquatic toxicity data show that the M07 and M08 degradates are less toxic to aquatic animals and plants than parent saflufenacil. Therefore, acute toxicity endpoints for both parent saflufenacil and the BAS 781 02H formulation are considered for freshwater aquatic animals and plants, where available.

Table 3.10. Summary of Most Toxic Acute and Chronic Toxicity Data for Aquatic Organisms Exposed to Saflufenacil Technical and Formulated Products.

Aquatic Animals					
Species (Test Substance)	**Acute Toxicity**			**Chronic Toxicity**	
	96-hr LC_{50}/EC_{50} (mg a.i./L)	**48-hr EC_{50} (mg a.i./L)**	**Toxicity Classification (MRID)**	**NOAEC/ LOAEC (mg a.i./L)**	**Endpoints (MRID)**
Bluegill sunfish *Oncorhynchus mykiss* (TGAI: BAS 800 H)	>108	--	Practically non-toxic (47127905)	--	--
Rainbow Trout *Oncorhynchus mykiss* (BAS 781 02H)	17.7 mg form/L (1.10 mg a.i./L)*	--	Slightly toxic (47560401)	--	--
Fathead minnow *Pimephales promelas* (TGAI: BAS 800 H)	--	--	--	0.997 / 3.32	Embryo survival (47127908)
Sheepshead Minnow *Cyprinodon variegates* (TGAI: BAS 800 H)	>98	--	Practically non-toxic (47127906)	--	--
Waterflea *Daphnia magna* (TAGI: BAS 800 H)	--	>98	Practically non-toxic (47127901)	1.33 / 2.64	Parental mortality and parental length (47127907)
Waterflea *Daphnia magna* (BAS 781 02H)	--	13.6 mg form/L (0.85 mg a.i./L)*	Slightly toxic (47560402)	--	--
Mysid *Americanmysis bahia* (TGAI: BAS 800 H)	8.5	--	Slightly toxic (47127903)	--	--
Eastern oyster *Crassostrea virginica* (TGAI: BAS 800 H)	>6.08	--	Not toxic at limit of solubility (47127902)	--	--

Table 3.10. Summary of Most Toxic Acute and Chronic Toxicity Data for Aquatic Organisms Exposed to Saflufenacil Technical and Formulated Products.		
Aquatic Plants		
Species	**Endpoint (mg a.i./L)**	**Effect (MRID)**
Freshwater Algae *Pseudokirchneriella subcapita* (TGAI: BAS 800 H)	96 hr EC_{50} = 0.042 EC_{05} = 0.015	Cell yield (47127923)
Freshwater Algae *Pseudokirchneriella subcapita* (BAS 781 02H)	96 hr EC_{50} = 0.014 mg form/L (0.0008 mg a.i./L)* NOAEC = 0.0039 mg form/L (0.0002 mg a.i./L)*	Biomass (47560403)
Duckweed *Lemna gibba* (TGAI: BAS 800 H)	7-day EC_{50} = 0.087 NOAEC = 0.01	Frond count (47127922)
Duckweed *Lemna gibba* (BAS 781 02H)	7-day EC_{50} = 0.023 mg form/L (0.001 mg a.i./L)* NOAEC = 0.001 mg form/L (0.00006 mg a.i./L)*	Biomass (47560404)

* Toxicity values for the BAS 781 02H formulation are adjusted to account for % a.i. of saflufenacil (6.24%)

3.3.2.1. Toxicity to Freshwater Fish

As shown in **Table 3.11**, two freshwater fish acute toxicity studies using the technical grade active ingredient (TGAI; BAS 800 H) were submitted to evaluate the toxicity of saflufenacil to fish in support of the new chemical registration. Results from two submitted static acute toxicity tests with freshwater fish show no effects, including sublethal effects, to the species at the single treatment level tested in limit tests. The reported 96-hr LC_{50} values fall in the range of >108 to >112 mg a.i./L; therefore, saflufenacil technical (BAS 800 H) is classified as practically non-toxic to freshwater fish on an acute exposure basis.

One additional freshwater fish acute static toxicity study using the formulated product BAS 781 02H (54.6% dimethenamid-p and 6.2% saflufenacil) was submitted for the rainbow trout (*Oncorhynchus mykiss*) (**Table 3.11**). Based on the results of this study, a 96-hr LC_{50} value of 17.7 mg form/L (1.10 mg a.i. saflufenacil/L) was reported. In addition, sublethal effects (*i.e.*, surfacing and hyperventilation) were observed at the 10 and 20 mg form/L test concentrations; therefore, the corresponding NOAEC for sublethal effects was reported as 2.5 mg form/L. Although the results of this study show that the BAS 781 02H formulation is more toxic than technical grade saflufenacil, it can be concluded that dimethenamid-p, not saflufenacil, contributes to the toxicity of the BAS 781 02H formulation, based on comparison of the results of the rainbow trout 96-hr LC_{50} for technical dimethenamid-p of 6.3 mg a.i./L (MRID 44332227) and technical saflufenacil of >112 mg a.i./L (MRID 47127904). Comparison of the dimethenamid-p a.i.-adjusted LC_{50} value for the BAS 781 02H formulated product (9.66 mg a.i./L) with the LC_{50} value for the dimethenamid-p a.i. (6.3 mg a.i./L) shows that synergistic effects between dimthenamid-p and saflufenacil are unlikely to occur. The BAS 781 02H formulation is classified as slightly toxic to freshwater fish on an acute exposure basis.

Table 3.11. Freshwater Fish Acute Toxicity to Saflufenacil Technical and BAS 781 02H Formulation.					
Test Species/ Test Substance (Flow-through/Static)	**% a.i.**	**96-hour LC_{50} (95% C.I.) (Measured/ Nominal)/ Slope**	**Toxicity Category**	**MRID No.**	**Study Classification**
Bluegill sunfish (*Lepomis macrochirus*) **BAS 800 H** (Static)	93.8	**>108 mg a.i./L** (Measured) Slope = NA	Practically non-toxic	47127905	Acceptable
Rainbow trout (*Oncorhynchus mykiss*) **BAS 800 H** (Static)	93.8	>112 mg a.i./L (Measured) Slope = NA	Practically non-toxic	47127904	Acceptable
Rainbow trout (*Oncorhynchus mykiss*) **BAS 781 02H** (Static)	6.2	17.7 (10-40) mg form/L (Nominal) (1.10 mg a.i./L)* Slope = NA	Slightly toxic	47560401	Acceptable

* Toxicity values for the BAS 781 02H formulation are adjusted to account for % a.i. of saflufenacil (6.24%)

A freshwater fish chronic early life stage toxicity test was submitted for fathead minnow (*Pimephales promelas*) with saflufenacil technical (BAS 800 H) (**Table 3.12**). The test was conducted for a duration of 33 days under flow-through conditions. A slight (5%), but statistically-significant reduction in embryo survival was detected at the two highest treatment levels of 3.32 and 9.63 mg a.i./L with corresponding NOAEC and LOAEC values of 0.997 mg a.i./L and 3.32 mg a.i./L, respectively. No treatment-related effects were observed during the study on larval or juvenile survival, time to hatch or time to swim-up, or growth. In addition, no sublethal effects were observed.

As previously discussed in **Section 3.3.1**, saflufenacil belongs to the LDPH class of pesticides, which have potentially enhanced toxicity in the presence of UV light, and tests conducted under standard laboratory lighting may underestimate the toxicity of saflufenacil to some taxa under natural sunlight conditions. Therefore, an interim enhanced toxicity adjustment factor of 29x, which is based on one available modified light and standard light ELS fish data for oxyfluorfen, is used to account for the potential enhanced toxicity.. Measured effects in the oxyfluorfen ELS studies were embryo and larvae survival and growth parameters. The 29x factor is expressed as the ratio of the "standard lighting: enhanced UV lighting" NOAEC values or 38:1.3 µg/L, respectively. It should be noted, however, that the oxyfluorfen modified light study had limitations in that the amount of UV light was relatively low. Uncertainties associated with application of the interim enhanced toxicity adjustment factor of 29x to chronic fish data are discussed further as part of the risk description.

The measured value of 0.997 mg a.i./L from the fathead minnow ELS study is used to derive RQs in the risk estimation, and the LDPH-adjusted value of 0.034 mg a.i./L (0.997 / 29) is used qualitatively in the risk description to bracket the potential for enhanced toxicity in the presence of UV light.

Table 3.12. Freshwater Fish Chronic Toxicity to Saflufenacil Technical.					
Test Species (Flow-through/Static; Duration)	**% a.i.**	**NOAEC/LOAEC (Measured/ Nominal)**	**Effect**	**MRID No.**	**Study Classification**
Fathead minnow (*Pimephales promelas*) (Flow-through; 33 days)	93.8	NOAEC = 0.997 mg a.i./L LOAEC = 3.32 mg a.i./L (Measured) (Adjusted NOAEC = 0.034 mg a.i./L)*	Embryo survival	47127908	Acceptable

* Adjusted fish chronic toxicity endpoint = 0.997 mg a.i./L divided by enhanced toxicity adjustment factor of 29.

3.3.2.2. Toxicity to Freshwater Invertebrates

Freshwater invertebrate acute toxicity data for the waterflea (*Daphnia magna*) are available for TGAI saflufenacil (BAS 800 H) and the BAS 781 02H formulated product, and are presented in **Table 3.13**. The 48-hr EC_{50} value for *Daphnia* exposure to the TGAI saflufenacil is >98 mg a.i./L, classifying saflufenacil as practically non-toxic to freshwater invertebrates on an acute exposure basis. After 48 hours of exposure, 10% immobility was observed at the highest test concentration of 98 mg a.i./L; however, there was no significant difference from the control. In addition, no sublethal effects were reported.

The available acute data for the BAS 781 02H formulation show that it is more toxic to freshwater invertebrates than technical grade saflufenacil with a reported 48-hr EC_{50} value of 13.6 mg form/L (0.85 mg saflufenacil a.i./L). In addition, sublethal effects (*i.e.*, lethargy) were observed at the 11 and 18 mg form/L test; therefore, the corresponding NOAEC for sublethal effects was reported as 6.5 mg form/L. Although the results of this study show that the BAS 781 02H formulation is more toxic than technical grade saflufenacil, it can be concluded that dimethenamid-p, not saflufenacil, contributes to the toxicity of the BAS 781 02H formulation, based on comparison of the results of the daphnia 48-hr EC_{50} for technical dimethenamid-p of 12 mg a.i./L (MRID 44332229) and technical saflufenacil of >98 mg a.i./L (MRID 47127901). Comparison of the dimethenamid-p a.i.-adjusted EC_{50} value for the BAS 781 02H formulated product (7.42 mg a.i./L) with the LC_{50} value for the dimethenamid-p a.i. (12 mg a.i./L) shows that synergistic effects between dimthenamid-p and saflufenacil are unlikely to occur. The BAS 781 02H formulation is classified as slightly toxic to freshwater invertebrates on an acute exposure basis.

Table 3.13. Freshwater Invertebrate Acute Toxicity to Saflufenacil Technical and BAS 781 02H Formulation.					
Test Species/ Test Substance (Flow-through/Static)	**% a.i.**	**48-hour EC_{50} (95% C.I.) (Measured/Nominal)/Slope**	**Toxicity Category**	**MRID No.**	**Study Classification**
Waterflea (*Daphnia magna*) **BAS 800 H** (Static)	93.8	**>98 mg a.i./L** (Measured) Slope = NA	Practically non-toxic	47127901	Acceptable
Waterflea (*Daphnia magna*) **BAS 781 02H** (Static)	6.2	**13.6 (12.3-15.3) mg form/L** (Nominal) (0.85 mg a.i./L)* Slope = 13.7 (8.12-19.2)	Slightly toxic	47560402	Acceptable

* Toxicity values for the BAS 781 02H formulation are adjusted to account for % a.i. of saflufenacil (6.24%)

One chronic full life cycle toxicity test using the TGAI was submitted to evaluate the toxicity of saflufenacil to aquatic freshwater invertebrates over 21 days in static-renewal conditions. The results of the study, which are summarized in **Table 3.14**, indicate statistically-significant parental morality (30%) as well as a 5% reduction in the growth (terminal length) of surviving adults at the 2.64 mg a.i./L treatment level; the corresponding NOAEC is 1.33 mg a.i./L.

Table 3.14. Freshwater Invertebrate Chronic Toxicity to Saflufenacil Technical					
Test Species (Flow-through/Static; Duration)	**% a.i.**	**NOAEC/LOAEC (Measured/ Nominal)/**	**Effect**	**MRID No.**	**Study Classification**
Waterflea (*Daphnia magna*) (Static-renewal; 21 days)	93.9	NOAEC = 1.33 mg a.i./L LOAEC = 2.64 mg a.i./L (Measured)	Parental mortality and parental length	47127907	Acceptable

One additional spiked sediment toxicity study, which is summarized in **Table 3.15**, was submitted by the registrant to assess the potential effects of saflufenacil on the sediment-dwelling freshwater invertebrate midge (*Chironomus riparius*). The study, which followed the OECD Guideline 218 methods for sediment-water chironomid toxicity testing using spiked sediment, was classified as "Supplemental" because it is a non-guideline study. The results of the study indicate that BAS 800 H has a low affinity for sediment and quickly partitions from the sediment into pore water and then into overlying water. Although not statistically-significant, a biologically significant reduction in emergence rate (17% of the control) was observed at the 2.79 mg a.i./kg dw treatment level (mean-measured LOAEC values for pore water and overlying water were 18.2 mg a.i./L and 1.24 mg a.i./L, respectively). Corresponding NOAEC values were 2.07 mg a.i./kg dw (in sediment), 10.2 mg a.i./L (in pore water), and 0.652 mg a.i./L (in overlying water). Given the propensity for saflufenacil to partition from sediment into the water, the endpoint associated with mean-measured concentrations in pore water is used to assess the potential toxicity of saflufenacil to sediment-dwelling freshwater invertebrates. Although the overlying water endpoints are lower than those for pore water, the pore water concentrations are used because it is presumed that chironomids would be exposed to pore water in the sediment, rather than concentrations in the water column.

Table 3.15. Toxicity of Sediment-Dwelling Freshwater Invertebrates to Saflufenacil Technical					
Test Species Test Substance (Flow-through / Static; Duration)	**% a.i.**	**Endpoint (Measured/ Nominal)/**	**Effect**	**MRID No.**	**Study Classification**
Chironomus riparius (Static; 28 days; spiked sediment)	93.8	Sediment: NOAEC = 2.07 mg a.i./kg dw LOAEC = 2.79 mg a.i./kg dw (Initial Measured) Pore Water: **NOAEC = 10.2 mg a.i./L** **LOAEC = 18.2 mg a.i./L** (Mean-measured) Overlying Water: NOAEC = 0.652 mg a.i./L LOAEC = 1.24 mg a.i./L (Mean-measured)	Emergence rate	47127910	Supplemental (non-guideline study)

3.3.2.3. Toxicity to Estuarine/Marine Fish

One estuarine/marine fish acute toxicity study with the TGAI was required to evaluate the toxicity of saflufenacil to fish in support of the new registration. Results from the submitted static acute test are listed in **Table 3.16** below. No mortality or sublethal effects were observed at the highest test concentration; the LC_{50} value for sheepshead minnow (*Cyprinodon variegates*) is >98 mg a.i./L. Therefore, saflufenacil technical is classified as practically non-toxic to estuarine/marine fish on an acute exposure basis.

Table 3.16. Estuarine/Marine Fish Acute Toxicity to Saflufenacil Technical.					
Test Species (Flow-through/Static)	**% a.i.**	**96-hour LC_{50} (95% C.I.) (Measured/ Nominal)/ Slope**	**Toxicity Category**	**MRID No.**	**Study Classification**
Sheepshead Minnow (*Cyprinodon variegatus*) (Static)	93.8	>98 mg a.i./L (Measured) Slope = NA	Practically non-toxic	47127906	Acceptable

Chronic toxicity data for estuarine/marine fish are not available. It is not possible to derive an acute-to-chronic ratio (ACR) for estuarine/marine fish based on freshwater fish data because all of the freshwater fish LC_{50} values are non-definitive "greater than" values (ranging from >108 to >112 mg a.i./L).

3.3.2.4. Toxicity to Estuarine/Marine Invertebrates

Estuarine/marine invertebrate acute toxicity data for saflufenacil technical and its M07 degradate are summarized in **Table 3.17**. The 96-hr LC_{50} value for mysid shrimp (*Americamysis bahia*) exposure to the TGAI is 8.5 mg a.i./L, classifying saflufenacil as moderately toxic to estuarine/marine invertebrates on an acute exposure basis. Acute mysid shrimp exposure to the M07 degradate indicates that it is also practically non-toxic to estuarine/marine invertebrates on an acute exposure basis with a 96-hr LC_{50} value of >98 mg a.i./L.

In a 96-hr flow-through shell deposition study with estuarine/marine mollusks, the EC_{50} value for the Eastern oyster (*Crassostrea virginica*) was reported as >6.08 mg a.i./L, the highest exposure concentration tested. At 96-hr, no mortalities occurred and mean shell deposition was greater in all treatment levels relative to the negative control. According to the study authors, the highest nominal concentration for the definitive oyster shell deposition test was selected to test up to the apparent limit of solubility in the test system. Further examination of the toxicity data for other estuarine/marine animals including the sheepshead minnow and mysid indicate no issues associated with solubility at test concentrations up to 98 mg a.i./L and pH levels comparable with those measured in the oyster study (within 7.8 to 8.1 for all species tested). However, increased salinity in the oyster study (30-34 ‰) as compared to the sheepshead minnow (19-21‰) and mysid (18-20‰) may have accounted for observed decrease in solubility of saflufenacil in the acute study. Beyond the differences in salinity, it is unclear why saflufenacil exhibited decreased solubility in the acute oyster shell deposition study. Based on the available data, it appears that saflufenacil is at most, moderately toxic to oysters on an acute exposure basis.

Table 3.17. Estuarine/Marine Invertebrate Acute Toxicity to Saflufenacil Technical and M07 Degradate.

Test Species Test Substance (Flow-through/Static)	**% a.i.**	**96-hour LC/EC_{50} (95% C.I.) (Measured/ Nominal) Slope**	**Toxicity Category**	**MRID No.**	**Study Classification**
Mysid (*Americamysis bahia*) **BAS 800 H** (Flow-through)	93.8	**LC_{50} = 8.5 (7.4-11) mg a.i./L** (Measured) Slope = 2.51 (1.28-3.73)	Moderately toxic	47127903	Acceptable
Mysid (*Americamysis bahia*) **M07 Degradate** (Static)	95.4	LC_{50} = >98 mg a.i./L (Measured) Slope = NA	Practically non-toxic	47560303	Acceptable
Eastern oyster (*Crassostrea virginica*) **BAS 800 H** (Flow-through)	93.8	Shell deposition EC_{50} = >6.08 mg a.i./L (Measured) Slope = NA	Moderately toxic	47127902	Acceptable

Chronic toxicity data for estuarine/marine invertebrates are not available. It is not possible to derive an acute-to-chronic ratio (ACR) for estuarine/marine invertebrates based on freshwater invertebrate data because the daphnid EC_{50} value from the limit test is a non-definitive "greater than" value (>98 mg a.i./L).

3.3.2.5. Toxicity to Aquatic Plants

Acute aquatic plant toxicity studies were submitted for non-vascular and vascular plants using the TGAI saflufenacil, the BAS 781 02H formulation, and the M07/M08 degradates. The results of these studies are summarized in **Table 3.18**.

Non-Vascular Aquatic Plants

Non-vascular aquatic plant data were submitted for freshwater green algae (*Pseudokirchneriella subcapitata*), freshwater blue-green algae (*Anabaena flos-aquae*), freshwater diatom (*Navicula pellicosa*), and marine diatom (*Skeletonema costatum*). The results of the acute non-vascular plant data, which are discussed in further detail below, indicate the following sensitivity to saflufenacil technical of the species tested: freshwater green algae > marine diatom > freshwater diatom > freshwater blue-green algae. The most sensitive endpoints for aquatic non-vascular plants are based on freshwater green algae for saflufenacil technical (BAS 800 H) and the more toxic BAS 781 02 H formulated product.

Four acute studies on the toxicity of saflufenacil technical, the BAS 781 02H formulation, and M07 and M08 degradates were submitted for non-vascular *P. subcapitata*. For saflufenacil technical, the 96-hr EC_{50} and NOAEC values were 0.042 mg a.i./L and <0.02 mg a.i./L, respectively, based on cell count and yield. Because effects were observed at all test concentrations, the EC_{05} value of 0.015 mg a.i./L (based on cell yield) is also reported and used in lieu of a definitive NOAEC to assess risks to listed aquatic plants (see **Table 3.10**). The available acute data for the BAS 781 02H formulation show that it is approximately three times more toxic to freshwater green algae than saflufenacil technical with a reported 96-hr EC_{50} value of 0.014 mg form/L (0.0008 mg a.i./L). Although the results of this study show that the BAS 781 02H formulation is more toxic than technical grade saflufenacil, it is likely that dimethenamid-p, not saflufenacil, contributes to the enhanced toxicity of the BAS 781 02H formulation, based on comparison of the results of the 5-day freshwater green algae EC_{50} for technical dimethenamid-p of 0.014 mg a.i./L (MRID 44332253) and technical saflufenacil of 0.042 mg a.i./L (MRID 47127923). Comparison of the dimethenamid-p a.i.-adjusted EC_{50} value for the BAS 781 02H formulated product (0.008 mg a.i./L) with the EC_{50} value for the dimethenamid-p a.i. (0.014 mg a.i./L) shows that additive or synergistic effects between dimthenamid-p and saflufenacil are unlikely to occur (*i.e.*, there is less than a factor of 2 difference between the EC_{50} value for the dimethenamid-p a.i. and the a.i.-adjusted EC_{50} value for the BAS 78 02H formulated product). The saflufenacil degradate data for M07 and M08 indicate lesser toxicity compared to the parent with respective EC_{50} values of >29 mg a.i./L and 25 mg a.i./L. Although a definitive EC_{50} value was derived for the M08 degradate, this study was classified as "supplemental" because a fine white precipitate was observed at the highest test concentration, the only concentration at which adverse effects were observed. Therefore, it is not possible to determine whether adverse effects should be attributed to the toxicity of the dissolved test substance or the precipitate.

Available acute toxicity data on saflufenacil technical for the other non-vascular plants indicates a fairly wide range in sensitivity of EC_{50} values, ranging from 0.18 mg a.i./L (for the marine diatom) to 37 mg a.i./L (for freshwater blue-green algae).

Vascular Aquatic Plants

Acute vascular plant data for saflufenacil technical, the BAS 781 02H formulated product, and the M07 and M08 degradates were submitted for duckweed (*Lemna gibba*). The 7-day EC_{50} and NOAEC values for technical saflufenacil were 0.087 mg a.i./L and 0.01 mg a.i./L, respectively, based on frond count. The available acute data for the BAS 781 02H formulation show that it is approximately four times more toxic to duckweed than saflufenacil technical with a reported 7-day EC_{50} value of 0.023 mg form/L. Although the results of this study show that the BAS 781 02H formulation is more toxic than technical grade saflufenacil, it is likely that dimethenamid-p, not saflufenacil, contributes to the enhanced toxicity of the BAS 781 02H formulation, based on comparison of the results of the 7-day EC_{50} for technical dimethenamid-p of 0.013 mg a.i./L (MRID 44332257) and technical saflufenacil of 0.087 mg a.i./L (MRID 47127922). Comparison of the dimethenamid-p a.i.-adjusted EC_{50} value for the BAS 781 02H formulated product (0.013 mg a.i./L) with the EC_{50} value for the dimethenamid-p a.i. (0.013 mg a.i./L) shows that additive or synergistic effects between dimthenamid-p and saflufenacil are unlikely to occur. The saflufenacil degradate data for M07 and M08 indicate lesser toxicity as compared to the parent with EC_{50} values of >30 mg a.i./L and 12 mg a.i./L, respectively.

Table 3.18. Acute Toxicity of Aquatic Plants to Saflufenacil Technical, BAS 781 02H Formulation, and M07 and M08 Degradates.

Test Species (Test Substance; Flow-through / Static; Duration)	% a.i.	Endpoint (Measured/ Nominal) Slope	Effect	MRID No.	Study Classification
Nonvascular Plants: Freshwater Green Algae					
Freshwater green algae *Pseudokirchneriella subcapitata* (**BAS 800 H**; Static; 96 hours)	93.8	**96-hr EC_{50} = 0.042 mg a.i./L** NOAEC = <0.02 mg a.i./L **EC_{05} = 0.015 mg a.i./L** (Measured) Slope = 3.76±0.127	Cell count and yield	47127923	Acceptable
Freshwater green algae *Pseudokirchneriella subcapitata* (**BAS 781 02H**; Static; 96 hours)	6.2	**96-hr EC_{50} = 0.014 mg form/L (0.0008 mg a.i./L)* NOAEC = 0.004 mg form/L (0.0002 mg a.i./L)*** (Nominal) Slope = 5.40±0.279	Biomass	47560403	Acceptable

Table 3.18. Acute Toxicity of Aquatic Plants to Saflufenacil Technical, BAS 781 02H Formulation, and M07 and M08 Degradates.					
Test Species (Test Substance; Flow-through / Static; Duration)	**% a.i.**	**Endpoint (Measured/ Nominal) Slope**	**Effect**	**MRID No.**	**Study Classification**
Freshwater green algae *Pseudokirchneriella subcapitata* (**M07 Degradate**; Static; 96 hours)	95.4	96-hr EC_{50} = >29 mg a.i./L NOAEC = 29 mg a.i./L (Measured) Slope = NA	No effect	47560301	Acceptable
Freshwater green algae *Pseudokirchneriella subcapitata* (**M08 Degradate**; Static; 96 hours)	97.2	96-hr EC_{50} = 25 mg a.i./L NOAEC = 16 mg a.i./L (Measured) Slope = NA	Yield and biomass	47560305	Supplemental (Precipitate observed at highest test concentration where effects were observed)
Nonvascular Plants: Freshwater Blue-Green Algae, Freshwater Diatom, and Marine Diatom					
Freshwater blue-green algae *Anabaena flos-aquae* (**BAS 800 H**; Static, 96 hours)	93.9	96-hr EC_{50} = 37 mg a.i./L NOAEC = 3.99 mg a.i./L (Measured) Slope = 1.72±0.115	Cell count and yield	47127925	Acceptable
Freshwater diatom *Navicula pelliculosa* (**BAS 800 H**; Static, 96 hours)	93.8	96-hr EC_{50} = 1.8 mg a.i./L NOAEC = 0.75 mg a.i./L (Measured) Slope = 2.12±0.245	Cell density	47127924	Acceptable
Marine diatom *Skeletonema costatum* (**BAS 800 H**; Static, 96 hours)	93.8	96-hr EC_{50} = 0.18 mg a.i./L NOAEC = 0.054 mg a.i./L (Measured) Slope = 1.07±0.132	Cell density	47127926	Acceptable
Vascular Plants: Duckweed					
Duckweed *Lemna gibba* (**BAS 800 H**; Static-renewal; 7 days)	93.9	**7-D EC_{50} = 0.087 mg a.i./L NOAEC = 0.01 mg a.i./L** (Measured) Slope = 2.32±0.123	Frond count	47127922	Acceptable
Duckweed *Lemna gibba* (**BAS 781 02 H**; Static-renewal; 7 days)	6.2	**7-D EC_{50} = 0.023 mg form/L (0.001 mg a.i./L)* NOAEC = 0.001 mg form/L (0.00006 mg a.i./L)*** (Nominal) Slope =0.854±0.109	Biomass	47560404	Acceptable

Table 3.18. Acute Toxicity of Aquatic Plants to Saflufenacil Technical, BAS 781 02H Formulation, and M07 and M08 Degradates.					
Test Species (Test Substance; Flow-through / Static; Duration)	**% a.i.**	**Endpoint (Measured/ Nominal) Slope**	**Effect**	**MRID No.**	**Study Classification**
Duckweed *Lemna gibba* (**M07 Degradate**; Static; 7 days)	95.4	7-D EC_{50} = >30 mg a.i./L NOAEC = 30 mg a.i./L (Measured) Slope = NA	No effect	47560302	Acceptable
Duckweed *Lemna gibba* (**M08 Degradate**; Static; 7 days)	97.2	7-D EC_{50} = 12 mg a.i./L NOAEC = 5.2 mg a.i./L (Measured) Slope = NA	Biomass	47560306	Acceptable

* Toxicity values for the BAS 781 02H formulation are adjusted to account for % a.i. of saflufenacil (6.24%)

3.3.2 Terrestrial Effects Characterization

A summary of the most sensitive terrestrial animal toxicity data for saflufenacil technical and its formulated products is provided in **Table 3.19** and discussed further in **Sections 3.3.2.1** through **3.3.2.3**. The available Tier II terrestrial plant toxicity data for saflufenacil technical and its M07 and M08 degradates are provided in **Section 3.3.2.4.**

As previously discussed in **Section 3.3.1**, exposure of terrestrial organisms to LDPHs may result in the accumulation of heme and chlorophyll precursors called protoporphyrins, which, in the presence of ultraviolet light, may produce activated oxygen radicals that can potentially disrupt cellular function. Therefore, particular attention is paid to any hematologic effects observed in the available terrestrial animal toxicity studies.

Table 3.19. Summary of Acute and Chronic Toxicity Data for Terrestrial Animals Exposed to Saflufenacil Technical.[1]						
	Acute Toxicity				**Chronic Toxicity**	
Species/ Chemical	**48-hr LD_{50} µg a.i./bee**	**14-day LD_{50} (mg a.i./kg bw)**	**8-day LC_{50} (mg a.i./kg diet (ppm)**	**Toxicity Classification (MRID)**	**NOAEC/ LOAEC (mg a.i./kg diet (ppm))**	**Endpoints (MRID)**
Bobwhite Quail (*Colinus virginianus*)	NA	>2,000	>5,270	Practically non-toxic (47127911 and 47127913)	96 / 282	Hatchling body weight (47699904)
Mallard Duck (*Anas platyrhynchos*)	NA	>2,000	>5,275	Practically non-toxic (47127912 and 47127914)	279 / 940	Proportion of 3-wk embryos to viable embryos (47127916)

Table 3.19. Summary of Acute and Chronic Toxicity Data for Terrestrial Animals Exposed to Saflufenacil Technical.[1]						
	Acute Toxicity				**Chronic Toxicity**	
Species/ Chemical	**48-hr LD_{50} µg a.i./bee**	**14-day LD_{50} (mg a.i./kg bw)**	**8-day LC_{50} (mg a.i./kg diet (ppm)**	**Toxicity Classification (MRID)**	**NOAEC/ LOAEC (mg a.i./kg diet (ppm))**	**Endpoints (MRID)**
Wistar rat (*Ratus norvegicus*)	NA	>2,000[2]	--	Practically non-toxic (47128101)	NOAEL =15 mg a.i./kg-bw/day LOAEL = 50 mg a.i./kg-bw/day	Pup mortality and reduced weight gain (47128117)
Honey Bee (*Apis mellifera*)	>100[3]	--	--	Practically non-toxic (47127919)	--	--

[1] All reported data are for saflufenacil technical (BAS 800 H), unless otherwise noted.
[2] Available acute oral mammalian LD_{50} data for BAS 800 01H and BAS 781 02H indicate that these formulated products are also practically non-toxic to mammals on an acute oral basis (LD_{50} values for both formulated products are >2,000 mg/kg-bw; MRID 47128208).
[3] Available acute contact honey bee data for BAS 800 01H indicate that this formulated is also practically non-toxic to honey bees on an acute contact basis (LD_{50} value = >100 µg a.i./bee; MRID 47445903). Additionally, the acute oral LC_{50} for honey bee exposure to the BAS 800 01H formulation is >121 µg a.i./bee.

3.3.2.1. Toxicity to Birds

Avian acute oral toxicity studies using the TGAI were submitted for bobwhite quail (*Colinus virginianus*) and mallard duck (*Anas platyrhynchos*) to establish the toxicity of saflufenacil to birds. Results of these tests are presented in **Table 3.20** below. The LD_{50} values for the bobwhite quail and mallard duck are >2,000 mg/kg body weight (BW); therefore, saflufenacil is classified as practically non-toxic to avian species on an acute oral exposure basis. In addition, no sublethal/behavioral effects or treatment-related clinical signs of toxicity on body weight or feed consumption were observed.

As a result of the new CFR 40 Part 158 data requirements, avian acute oral data are now required for one passerine species and either a waterfowl or an upland game species for all new federal actions including Section 3 new chemical registrations. Given that no acute oral passerine data are available for saflufenacil, the uncertainties associated with this data gap are discussed further in the risk description in **Section 4.2.2.1**.

Table 3.20. Avian Acute Oral Toxicity to Saflufenacil Technical.					
Test Species	**% a.i.**	**LD_{50} (mg a.i./kg BW) Slope**	**Toxicity Category**	**MRID No.**	**Study Classification**
Northern bobwhite quail (*Colinus virginianus*)	93.8	>2,000 Slope = NA	Practically non-toxic	47127911	Acceptable
Mallard duck (*Anas platyrhynchos*)	93.8	>2,000 Slope = NA	Practically non-toxic	47127912	Acceptable

Avian subacute dietary toxicity tests were required for upland game and waterfowl bird species. Results of the two submitted tests are listed in **Table 3.21** below. The LC_{50} values for the bobwhite quail and mallard duck are greater than the highest mean-measured treatment levels of 5,270 and 5,275 mg/kg-diet, respectively; therefore, saflufenacil is classified as practically non-toxic to avian species on a subacute dietary exposure basis. Although no treatment-related sublethal effects related to body weight changes or clinical signs of toxicity were observed in the bobwhite quail study, visual assessment of the food consumption data (g/bird/day) in the mallard duck study indicates a clear, yet non-significant, decrease in food consumed at the highest test concentration (5,270 mg/kg-diet). The study authors do not indicate whether there were any palatability issues associated with the decrease in food consumption. Based on this effect, a NOAEC value of 2,023 mg/kg-diet was reported for the mallard duck sub-acute dietary study.

Table 3.21. Avian Subacute Dietary Toxicity to Saflufenacil Technical.

Test Species	% a.i.	8-Day LC_{50} (mg a.i./kg-diet) (Measured/Nominal) Slope	Toxicity Category	MRID No.	Study Classification
Northern bobwhite quail (*Colinus virginianus*)	93.8	**>5,270** (Measured) Slope = NA	Practically non-toxic	47127913	Acceptable
Mallard duck (*Anas platyrhynchos*)	93.8	>5,275 (Measured) Slope = NA	Practically non-toxic	47127914	Acceptable

Two avian reproduction tests using the TGAI were submitted to establish the chronic toxicity of saflufenacil to birds. Results from these studies are summarized in **Table 3.22** below. The most sensitive chronic avian endpoint is based on a 5.4% and 9.5% reduction in bobwhite quail hatchling body weight at the two highest test concentrations (282 and 940 mg a.i./kg-diet, respectively), with a corresponding NOAEC of 96 mg a.i./kg-diet. In the mallard duck reproduction study, a significant, but slight (3%) reduction was detected for the proportion of live 3-week embryos to viable embryos at the highest treatment level of 940 mg a.i./kg-diet. Aside from reduction in bobwhite quail hatchling body weight and ratio of 3-wk old duckling embryos to viable embryos, no other effects, including behavioral effects, were observed on any adult or offspring parameter in the submitted avian reproduction studies for saflufenacil.

Table 3.22. Avian Chronic Toxicity to Saflufenacil Technical.

Test Species	% a.i.	NOAEC/LOAEC (mg a.i./kg-diet)	Effect	MRID No.	Study Classification
Northern bobwhite quail (*Colinus virginianus*)	93.8	**NOAEC = 96 LOAEC = 282**	Hatchling body weight	47699904	Acceptable
Mallard duck (*Anas platyrhynchos*)	93.8	NOAEC = 279 LOAEC = 940	Proportion of 3-wk embryos to viable embryos	47127916	Acceptable

3.3.2.2. Toxicity to Mammals

Three mammalian acute oral toxicity studies using the TGAI and two formulated products (BAS 800 01H and BAS 781 02H) were submitted to establish the toxicity of saflufenacil to mammals. Results of these tests are presented in **Table 3.23** below. The acute mammalian oral LD_{50} values exceed 2,000 mg/kg bw; therefore, saflufenacil and its BAS 800 01H and BAS 781 02H formulated products are classified as practically non-toxic to mammals on an acute oral exposure basis. No mortality, clinical signs, or macroscopic pathologic abnormalities were observed in rats exposed to saflufenacil (BAS 800 H). Exposure to the BAS 800 01 formulation resulted in no mortalities; however, clinical observation revealed impaired general state, dyspnoea (labored breathing), and piloerection for up to 5 hours after dosing. One of six rats died 5 hours after dosing with 2,000 mg/kg bw of the BAS 781 02H formulated product, and a number of clinical observations, including impaired and poor general condition, dyspnoea, apathy, staggering, tremor, twitching, salivation, lacrimation, abdominal and lateral position (i.e., lying on their stomach and/or side) were observed for up to 5 hours.

Table 3.23. Mammalian Acute Oral Toxicity to Saflufenacil Technical and Formulated Products (BAS 800 01H and BAS 781 02H).

Test Species (Test Substance)	% a.i.	LD_{50} (mg a.i./kg- BW) Slope	Toxicity Category	MRID No.	Study Classification
Wistar rat **(BAS 800 H)**	93.8	>2,000 Slope = NA	Practically non-toxic	47128101	Acceptable
Wistar rat **(BAS 800 01H formulation)**	69.9	>2,000 Slope = NA	Practically non-toxic	47127208	Acceptable
Wistar rat **(BAS 781 02H formulation)**	6.2	>2,000 Slope = NA	Practically non-toxic	47127208	Acceptable

A 2-generation Wistar rat (*Ratus norvegicus*) reproduction study using the TGAI was submitted to establish the toxicity of saflufenacil to mammals over prolonged periods. Results from this test are listed in **Table 3.24** below. Based on increased stillborn pups, increased pup mortality during the early phase of lactation, and reduced pup weight gains, the LOAEL and NOAEL for reproductive and offspring toxicity were reported as 50 and 15 mg a.i./kg-bw/day, respectively. In addition, it is important to note that anemia and other hematologic effects were observed in the rat dietary reproduction study. Following dietary exposure to BAS 800 H for approximately 15 to 19 weeks (including pregnancy in females), the rats showed signs of hypochromic, microcytic anemia. Hemoglobin concentrations and other indices of the red blood cell (*i.e.*, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, and reduced mean corpuscular hemoglobin concentration) were decreased in both sexes at 50 mg a.i./kg-bw day. It is possible that the observed anemia and hematologic effects in mammalian studies may be associated with accumulation of protoporphryins (porphyria). Given the lack of natural sunlight in the laboratory where such tests are conducted, it is possible that hematologic effects have the potential to become more pronounced in wild populations via phototoxic effects associated with the accumulation of protoporphyrins.

Table 3.24. Mammalian Chronic Toxicity of Saflufenacil Technical.					
Test Species	**% a.i.**	**NOAEL/ LOAEL (mg a.i./kg-bw/day)**	**Effect**	**MRID No.**	**Study Classification**
Wistar rat (*Ratus norvegicus*)	93.8	NOAEL = 15 LOAEL = 50	Pup mortality and reduced weight gain	47128117	Acceptable

3.3.2.3. Toxicity to Beneficial Insects

An acute contact toxicity study of bees is required, and two 48-hr acute contact toxicity studies using saflufenacil technical and the BAS 800 01H formulation were submitted to establish the toxicity of saflufenacil to honey bees (*Apis mellifera*). In addition, an acute oral toxicity test was submitted for the BAS 800 01H formulation. Based on the results of the acute contact studies, which are summarized in **Table 3.25**, only 5% and 2% mortality of bees were observed at the highest treatment levels of 100 µg a.i./bee for saflufenacil technical and the BAS 800 01H, respectively. Therefore, the reported LD_{50} values are >100 µg a.i./bee, and saflufenacil and the BAS 800 01H formulated product are categorized as practically non-toxic to honey bees on an acute contact exposure basis. The results of the supplemental non-guideline acute oral toxicity study with the BAS 800 01H formulation show similar results to the acute contact toxicity study with only 2% mortality occurring at the maximum treatment concentration of 121 µg a.i./bee; the reported LD_{50} value is >121 µg a.i./bee. It should be noted that there are uncertainties associated with the honey bee toxicity data because they examine effects only on young adult forage (female) bees and not on potential effects to the queen, drones (males), juvenile (nurse) and larval bees.

Table 3.25. Honeybee Acute Toxicity to Saflufenacil Technical and the BAS 800 01H Formulation.						
Test Species / Test Substance	**Exposure Route**	**% a.i.**	**Endpoint**	**Toxicity Category**	**Source**	**Study Classification**
Honeybee (*Apis mellifera*) **BAS 800 H**	Acute contact	93.8	48-hr LD_{50} = >100 µg a.i./bee Slope = NA	Practically non-toxic	47127917	Acceptable
Honeybee (*Apis mellifera*) **BAS 800 01H Formulation**	Acute contact	68.8	48-hr LD_{50} = >100 µg a.i./bee Slope = NA	Practically non-toxic	47445903	Acceptable
	Acute oral	68.8	48-hr LD_{50} = >121 µg a.i./bee Slope = NA	NA	47445903	Supplemental (non-guideline study)

As shown in **Table 3.26**, additional terrestrial invertebrate toxicity studies were submitted for earthworms (*Eisenia fetida*), the parasitic wasp (*Aphidius rhopalosiphi*), and the predatory mite (*Typhlodromus pyri*). The results of the earthworm toxicity tests with saflufenacil technical and the M08 degradate show no treatment-related lethal or sublethal effects following 14-days of exposure at 1,000 mg a.i./kg dw soil; therefore, the reported LC_{50} and NOAEC values were >1000 and 1000 mg a.i./kg dw soil, respectively.

Effects on two sensitive species, the parasitic wasp and predatory mite, were studied in dose-response tests on artificial substrate (glass plates) with the water-dispersible granule BAS 800 01H (70% saflufenacil) and the emulsifiable concentrate BAS 781 02H (6.1% saflufenacil; 53.6% dimethenamid-p). The BAS 800 01 LR_{50} values were 0.72 lbs product/A (0.51 lbs a.i./A) for the parasitic wasp and 0.58 lbs product/A (0.40 lbs a.i./A) for the predatory mite. The BAS 781 02 formulation was more toxic to both the parasitic wasp and the predatory mite with respective LR_{50} (lethal rate to 50% of the test population) values of 7.69 ml product/A (0.001 lbs a.i./A) and 115 ml product/A (0.015 lbs a.i./A). Effects on reproduction were not determined.

It should be noted that the BAS 781 02H LR_{50} values for the parasitic wasp and predatory mite are approximately 9 to 134 times less than the maximum application rate for the BAS 781 02H formulation of 0.134 lbs a.i./A. Given that terrestrial invertebrates toxicity data are not available for the dimethenamid-p active ingredient in the BAS 781 02H formulation, and no other guideline studies on honey bees are available for this formulated product, it is unclear whether the dimethenamid-p active ingredient contributes to the toxicity of the formulated product to terrestrial invertebrates, including pollinators. Submittal of a honeybee acute contact toxicity study for the BAS 781 02H formulation, completed in accordance with OPPTS 850.3020 would reduce the uncertainty associated with the observed toxicity of this formulation to sensitive arthropod species.

Table 3.26. Toxicity to Other Terrestrial Invertebrates and Beneficial Insects.					
Test Species / Test Substance	**Purity (% a.i.)**	**Endpoint**	**Effect**	**Source**	**Study Classification**
Earthworm *Eisenia fetida* **BAS 800 H**	93.8	14-day LC_{50} = >1000 mg a.i./kg dw soil NOAEC = 1000 mg a.i./kg dw soil Slope = NA	No effect	47127927	Acceptable
Earthworm *Eisenia fetida* **M08 Degradate**	95.1	14-day LC_{50} = >1000 mg a.i./kg dw soil NOAEC = 1000 mg a.i./kg dw soil Slope = NA	No effect	47560307	Acceptable
Parasitoid wasp *Aphidius rholaposiphi* **BAS 800 01H Formulation**	70.0	48-hr LR_{50} = 0.72 lb form/A (0.51 lbs a.i./A)	Mortality	47523804	Supplemental (non-guideline study)
Parasitoid wasp *Aphidius rholaposiphi* **BAS 781 02H Formulation**	6.1	48-hr LR_{50} = 7.69 ml form/A (0.001 lbs a.i./A)	Mortality	47523901	Supplemental (non-guideline study)
Predaceous mite *Typhlodromus pyri* **BAS 800 01H Formulation**	70.0	7-day LR_{50} = 0.58 lb form/A (0.40 lbs a.i./A)	Mortality	47430803	Supplemental (non-guideline study)
Parasitoid wasp (*Aphidius rholaposiphi*) **BAS 781 02H Formulation**	6.1	7-day LR_{50} = 115 ml form/A (0.015 lbs a.i./A)	Mortality	47523902	Supplemental (non-guideline study)

3.3.2.4. Toxicity to Terrestrial Plants

Terrestrial plant vegetative vigor and seedling emergence toxicity tests using monocots and dicots plants are required. Two Tier II terrestrial non-target plant studies were submitted for the water-dispersible granule BAS 800 01H (70% saflufenacil) and BAS 800 02H formulation (12% saflufenacil) to assess the toxicity of saflufenacil to terrestrial plants. In addition, seedling emergence studies were submitted for the M07 and M08 degradates of saflufenacil. The results of the non-target terrestrial plant studies for BAS 800 01H, BAS 800 02H, and the M07/M08 degradates are summarized in **Tables 3.27 through 3.29**. A summary of the most sensitive endpoints for monocots and dicots from the seedling emergence and vegetative vigor studies with the two formulations is provided in **Table 3.30**.

Based on the results of the submitted terrestrial plant toxicity tests for both formulated products, it appears that dicots are more sensitive than monocots in the vegetative vigor test, and dicots are more sensitive to foliar routes of exposure in the vegetative vigor test than the seedling emergence test. Monocots appear to be more sensitive to the vegetative vigor test for the BAS 800 02H formulation and more sensitive to the seedling emergence test for the BAS 800 01H formulation. However, all tested plants exposed to both formulated products, with the exception of wheat and bean in the seedling emergence tests for the BAS 800 01H formulation, exhibited adverse effects, such as reduced dry weight, survival, and plant length, following exposure to the saflufenacil formulations. As shown in **Table 3.30**, the results of both formulations are considered in deriving the most sensitive endpoints for terrestrial plants. With the exception of the monocot seedling emergence endpoint, which is derived from the BAS 800 01H study, all other terrestrial plant endpoints (*i.e.*, dicot seedling emergence and vegetative vigor and monocot vegetative vigor) are based on exposure to the BAS 800 01H formulation. Comparison of the most sensitive EC_{25} values for the two formulated products show similar levels of sensitivity, within a factor of 2 to 4 for both monocots and dicots.

In the Tier II seedling emergence toxicity test with the BAS 800 01H formulation (70% saflufenacil), the most sensitive monocot and dicot species are onion (*Allium cepa*) and cabbage (*Brassica oleracea*), respectively. EC_{25} values for onion and cabbage, which are based on a reduction in seedling emergence and percent survival, are 0.0014 and 0.0031 lb a.i./A, respectively; NOAEC values for both species are 0.000018 and 0.00156 lb a.i./A, respectively. For the BAS 800 02H formulation (12% saflufenacil), the most sensitive monocot and dicot species in the seedling emergence test are ryegrass (*Lolium perenne*) and oilseed rape (*Brassica napus*), based on reduced dry weight and decreased percent survival, respectively. EC_{25} values for ryegrass and oilseed rape are 0.0062 and 0.00087 lb a.i./A, respectively; NOAEC values for both species are 0.0127 and 0.0002 lb a.i./A, respectively.

For Tier II vegetative vigor studies with the BAS 800 01H formulation, the most sensitive monocot and dicot species are corn (*Zea mays*) and lettuce (*Lactuca sativa*), respectively. EC_{25} values for lettuce and corn, which are based on a reductions in percent survival and dry weight, are 0.00019 and 0.0082 lb a.i./A, respectively; NOAEC values for both species are 0.00016 and 0.0054 lb a.i./A, respectively. For the BAS 800 02H formulation, the most sensitive monocot and dicot species in the vegetative vigor test are onion and tomato (*Lycopersicon esculentum*), respectively, both of which are based on reduced dry weight. EC_{25} values for onion and tomato are 0.0030 and 0.0001 lb a.i./A, respectively; NOAEC values for both species are 0.0020 and 0.0000066 lb a.i./A, respectively.

As previously mentioned, seedling emergence tests were also conducted with the M07 and M08 degradates of saflufenacil. In both studies with the degradates, the test substance was incorporated into the soil; therefore, the doses are reported in terms of both lbs a.i./A and mg a.i./kg dry soil. No effect greater than 25% was observed in the seedling emergence tests, with the exception of the monocot, onion, in both the M07 and M08 tests and the dicot, tomato, in the M08 test. For M07, the seedling emergence EC_{25} and NOAEC values based on reduced onion dry weight, are 0.25 mg a.i./kg dry soil (equivalent to 0.1748 lbs a.i./A) and 0.1906 mg a.i./kg dry soil (equivalent to 0.1332 lbs a.i./A), respectively. The M07 EC_{25} values for all other tested plant species, with the exception of onion, are >0.3813 mg a.i./kg dry soil (equivalent to >0.2664 lbs a.i./A). For M08, the EC_{25} values for onion reduced dry weight and tomato decreased percent survival are 0.1577 mg a.i./kg dry soil (equivalent to 0.1095 lbs a.i./A) and 0.1443 mg a.i./kg dry soil (equivalent to 0.1002 lbs a.i./A), respectively; NOAEC values for onion and tomato are 0.0962 mg a.i./kg dry soil (equivalent to 0.0669 lbs a.i./A) and 0.1923 mg a.i./kg dry soil (equivalent to 0.1339 lbs a.i./A), respectively. The M08 EC_{25} values for all other tested plant species, with the exception of onion and tomato, are >0.3846 mg a.i./kg dry soil (equivalent to >0.2678 lbs a.i./A).

Table 3.27. Summary of Tier II Toxicity of BAS 800 01H (70% a.i.) to Non-target Terrestrial Plants.

Crop	Type of Study Species	EC_{25}* (lb a.i./A)	NOAEC* (lb a.i./A)	Endpoint Affected	MRID	Study Classification
Seedling Emergence						
Monocots	Corn	>0.319	0.038	Dry weight	47127919	Acceptable
	Onion	**0.0014**	**0.000018**[1]	**Seedling emergence**	47127919	Acceptable
	Ryegrass	0.0101	0.334	Dry weight	47127919	Acceptable
	Wheat	>0.334	0.334	None	47127919	Acceptable
Dicots	Bean	>0.334	0.038	None	47127919	Acceptable
	Cabbage	**0.0031**	**0.00156**	**Percent survival**	47127919	Acceptable
	Lettuce	0.0043	0.00453	Dry weight	47127919	Acceptable
	Rape	0.0065	0.00453	Dry weight	47127919	Acceptable
	Soybean	>0.114	0.114	Dry weight	47127919	Acceptable
	Tomato	0.0043	0.0127	Dry weight	47127919	Acceptable
Vegetative Vigor						
Monocots	Corn	**0.0082**	**0.0054**	**Dry weight**	47127921	Acceptable
	Onion	0.0093	0.0054	Dry weight	47127921	Acceptable
	Ryegrass	0.1134	0.0890	Dry weight	47127921	Acceptable
	Wheat	0.0116	0.0011	Dry weight	47127921	Acceptable
Dicots	Bean	0.0006	0.00017	Dry weight	47127921	Acceptable
	Cabbage	0.0011	0.0002[2]	Dry weight	47127921	Acceptable
	Lettuce	**0.00019**	**0.00016**	**Percent survival**	47127921	Acceptable
	Rape	0.0033	0.0026	Dry weight	47127921	Acceptable
	Soybean	0.0009	0.000032	Dry weight	47127921	Acceptable
	Tomato	0.0003	0.00017	Dry weight	47127921	Acceptable

* All endpoints are reported as the EC_{25} and NOAEC values, unless otherwise noted. Bolded values are the most sensitive endpoints.

[1] The NOAEC value for onion seedling emergence was less than the lowest treatment level (<0.00453 lbs a.i./A); therefore, the EC_{05} value is reported.[2] The NOAEC value for cabbage dry weight was less than the lowest treatment level (<0.0013 lbs a.i./A); therefore, the EC_{05} value is reported.

Table 3.28. Summary of Tier II Toxicity of BAS 800 02H (12% a.i.) to Non-target Terrestrial Plants.						
Crop	**Type of Study Species**	**EC_{25}* (lb a.i./A)**	**NOAEC* (lb a.i./A)**	**Endpoint Affected**	**MRID**	**Study Classification**
Seedling Emergence						
Monocots	Corn	>0.319	0.319	Dry weight	47127918	Acceptable
	Onion	0.0121	0.347	Dry weight	47127918	Acceptable
	Ryegrass	**0.0062**	**0.0127**	**Dry weight**	47127918	Acceptable
	Wheat	0.1189	0.1110	Dry weight	47127918	Acceptable
Dicots	Bean	0.12	0.0127	Percent survival	47127918	Acceptable
	Cabbage	0.00097	0.000629	Percent survival	47127918	Acceptable
	Lettuce	0.00087	0.00392	Dry weight	47127918	Acceptable
	Rape	**0.00087**	**0.0002**[1]	**Percent survival**	47127918	Acceptable
	Soybean	0.2069	0.111	Dry weight	47127918	Acceptable
	Tomato	0.0019	0.00413	Dry weight	47127918	Acceptable
Vegetative Vigor						
Monocots	Corn	0.0053	0.0027	Dry weight	47127920	Acceptable
	Onion	**0.0030**	**0.0020**	**Dry weight**	47127920	Acceptable
	Ryegrass	0.0257	0.026	Dry weight	47127920	Acceptable
	Wheat	0.0071	0.00023	Dry weight	47127920	Acceptable
Dicots	Bean	0.00018	0.00012	Plant height	47127920	Acceptable
	Cabbage	0.0015	0.0003[2]	Dry weight	47127920	Acceptable
	Lettuce	0.0002	0.00012	Dry weight	47127920	Acceptable
	Rape	0.0050	0.0027	Dry weight	47127920	Acceptable
	Soybean	0.00058	0.00028	Plant height	47127920	Acceptable
	Tomato	**0.0001**	**0.000066**	**Dry weight**	47127920	Acceptable

* All endpoints are reported as the EC_{25} and NOAEC values, unless otherwise noted. Bolded values are the most sensitive endpoints.

[1] The NOAEC value for oilseed rape percent survival was less than the lowest treatment level (<0.00143 lbs a.i./A); therefore, the EC_{05} value is reported.

[2] The NOAEC value for cabbage dry weight was less than the lowest treatment level (<0.0013 lbs a.i./A); therefore, the EC_{05} value is reported.

Table 3.29. Summary of Tier II Seedling EmergenceToxicity of M07 and M08 Degradates to Non-target Terrestrial Plants.						
Crop	**Type of Study Species**	**EC_{25}* (mg/kg dry soil)**	**NOAEC* (mg/kg dry soil)**	**Endpoint Affected**	**MRID**	**Study Classification**
M07 Seedling Emergence						
Monocots	Corn	>0.3813	0.3813	None	47560304	Acceptable
	Onion	**0.25**	**0.1906**	**Dry weight**	47560304	Acceptable
	Ryegrass	>0.3813	0.3813	Dry weight	47560304	Acceptable
	Wheat	>0.3813	0.3813	None	47560304	Acceptable
Dicots	Bean	>0.3813	0.3813	Dry weight	47560304	Acceptable
	Cabbage	>0.3813	0.3813	None	47560304	Acceptable
	Lettuce	>0.3813	0.3813	None	47560304	Acceptable
	Rape	>0.3813	0.3813	None	47560304	Acceptable
	Soybean	>0.3813	0.3813	None	47560304	Acceptable
	Tomato	>0.3813	0.3813	None	47560304	Acceptable
M08 Seedling Emergence						
Monocots	Corn	>0.3846	0.3846	None	47560308	Acceptable
	Onion	**0.1577**	**0.0962**	**Dry weight**	47560308	Acceptable
	Ryegrass	>0.3846	0.0962	Plant length	47560308	Acceptable
	Wheat	>0.3846	0.3846	None	47560308	Acceptable
Dicots	Bean	>0.3846	0.1923	Plant length	47560308	Acceptable
	Cabbage	>0.3846	0.3846	None	47560308	Acceptable
	Lettuce	>0.3846	0.0481	Percent survival	47560308	Acceptable
	Rape	>0.3846	0.3846	Plant length	47560308	Acceptable
	Soybean	>0.3846	0.3846	None	47560308	Acceptable
	Tomato	**0.1143**	**0.1923**	**Percent survival**	47560308	Acceptable

* All endpoints are reported as the EC_{25} and NOAEC values, unless otherwise noted. Bolded values are the most sensitive endpoints.

Table 3.30. Terrestrial Monocot and Dicot Endpoints (lbs a.i./acre) from the Saflufenacil Seedling Emergence and Vegetative Vigor Studies.					
Endpoint		**SEEDLING EMERGENCE**		**VEGETATIVE VIGOR**	
		BAS 800 01H Formulation (Max. Application Rate = 0.134 lbs a.i./acre)	**BAS 800 02H Formulation (Max. Application Rate = 0.356 lbs a.i. /A)**	**BAS 800 01H Formulation (Max. Application Rate = 0.134 lbs a.i./acre)**	**BAS 800 02H Formulation (Max. Application Rate = 0.356 lbs a.i. /A)**
EC_{25}	**Monocots**	**0.0014***	0.0062	0.0082	**0.003***
	Dicots	0.0031	**0.00087***	0.00019	**0.0001***
NOAEC	**Monocots**	**0.000018*[1]**	0.0127	0.0054	**0.002***
	Dicots	0.00156	**0.0002*[2]**	0.00016	**0.000066***

* The most sensitive endpoint is bolded and used to calculate RQs in this assessment.
[1] The NOAEC for the most sensitive species is below the lowest tested concentrations (<0.00453 lbs a.i./A); therefore, the EC_{05} value is reported.
[2] The NOAEC for the most sensitive species is below the lowest tested concentrations (<0.00143 lbs a.i./A); therefore, the EC_{05} value is reported.

4. Risk Characterization

4.1. Risk Estimation

Toxicity data and exposure estimates are used to evaluate the potential for adverse ecological effects on non-target species. As discussed previously this baseline-level assessment of saflufenacil relies on the deterministic RQ method to provide a metric of potential risks. The RQ provides a comparison of exposure estimates to toxicity endpoints (*i.e.*, the estimated exposure concentrations are divided by acute and chronic toxicity values). The resulting unitless RQs are compared to the Agency's LOCs, as shown in **Table 2.3**. LOCs are used by the Agency to indicate when the use of a pesticide, as directed by the label, has the potential to cause adverse effects to non-target organisms.

4.1.1. Aquatic Organisms

The highest baseline-level aquatic EECs were used to derive RQs. These exposure estimates were based on the non-agricultural use of saflufenacil at 0.356 lbs a.i./A and represent concentrations in surface water (exposure estimates for ground water were lower). Additional RQs were not derived because listed species LOCs were not exceeded based on this maximum use pattern and RQs for other use patterns resulting in lower EECs would also not exceed LOCs. Peak EECs are used to represent acute exposure to fish, aquatic invertebrates, and aquatic plants, and the highest 21-day and 60-day average EECs represent chronic exposure to aquatic invertebrates and fish, respectively.

4.1.1.1. Aquatic Animals

Table 4.1 lists RQs calculated for aquatic animals exposed to saflufenacil, based on the highest EECs listed in **Table 3.5** from the PRZM modeling scenario for the non-agricultural use pattern. Saflufenacil is classified as "practically non-toxic" to freshwater fish and invertebrates and estuarine/marine fish on an acute exposure basis. Acute RQs were derived only for estuarine/marine invertebrates because all other aquatic animals showed no or less than 50% effects at the highest treatment levels tested (*i.e.*, only non-definitive ">" LC/EC_{50} values were available for these taxa). Although saflufenacil is classified as "slightly toxic" to estuarine/marine invertebrates, the acute RQ based on the highest EEC for the non-agricultural use pattern is 0.0007 and is well below the Agency's acute listed species LOC of 0.05. Further discussion of the predicted exposure values relative to the levels at which no effects were observed for freshwater fish and invertebrates and estuarine/marine fish is provided as part of the risk description in **Section 4.2.1.1.** In addition, further characterization of the available freshwater fish and invertebrate acute toxicity data for the BAS 781 02H formulated product is provided as part of the risk description.

As shown in **Table 4.1**, chronic RQ values for freshwater fish and invertebrates are less than the Agency's LOC of 1.0 for chronic risk to aquatic animals. However, no chronic toxicity data are available for estuarine/marine invertebrates, which appear to be the most acutely sensitive of all of the aquatic animals tested. Estuarine/marine invertebrates (EC_{50} = 8.5 mg a.i./L) are more than 11 times (98/8.5) more sensitive to saflufenacil on an acute exposure basis than freshwater invertebrates (EC_{50} >98 mg a.i./L). Using an assumed acute to chronic ratio for freshwater invertebrates and comparing the daphnid and mysid data results in a NOAEC for mysids of < 0.115 mg a.i./L [(98/1.33) = 73.6; 8.5/73.6 = 0.115]. To trigger the Agency's chronic LOC, however, the estuarine/marine invertebrate NOAEC would need to be at least 5.6 µg a.i./L (using the 21-day EEC and an LOC of 1). Therefore, estuarine/marine invertebrates would need to be at least 238 times more sensitive to saflufenacil than freshwater invertebrates [daphnid NOAEC = 1.33 mg a.i./L; (1.33 mg a.i./L)/(0.0056 mg a.i./L) = 238] on a chronic exposure basis to exceed the Agency's chronic LOC for listed and non-listed species.

Although chronic RQs for freshwater fish are less than the Agency's LOCs, the toxicity data used to calculate these RQs were derived from toxicity tests conducted under standard laboratory lighting, which may underestimate the toxicity of saflufenacil under natural sunlight. Further characterization of the potential impacts of this potential underestimation of risk and application of an interim enhanced toxicity adjustment factor to the existing freshwater fish chronic data is provided as part of the risk description in **Section 4.2.1.1**.

Table 4.1. Aquatic Animal RQ Values for Exposure to Saflufenacil.

Taxa	Exposure	RQ Based on Non-agricultural Use Pattern
Estuarine/Marine Invertebrates	Acute	0.0007
Freshwater Fish	Chronic	0.005
Freshwater Invertebrates	Chronic	0.004

4.1.1.2. Aquatic Plants

As shown in **Table 4.2**, RQ values for all listed and non-listed vascular and non-vascular aquatic plants are less than the Agency's LOC of 1.0, based on the highest aquatic EEC for saflufenacil non-agricultural use patterns. Therefore, risks to aquatic plants associated with exposure to saflufenacil are not expected.

Table 4.2. Aquatic Plant RQ Values for Exposure to Saflufenacil.

Taxa		RQ Based on Non-agricultural Use Pattern
Aquatic vascular plants	Non-Listed	0.07
	Listed	0.58
Freshwater algae	Non-Listed	0.14
	Listed	0.39
Marine diatom	Non-Listed	0.03
	Listed	0.11

4.1.2. Terrestrial Organisms

4.1.2.1. Birds

Acute RQs are not calculated for birds because only non-definitive acute and sub-acute toxicity endpoints are available. Based on the available toxicity data, no acute mortality and/or sublethal effects were observed in any of the avian studies at the highest concentrations/doses tested. Although no treatment-related sublethal effects related to body weight changes or clinical signs of toxicity were observed in any of the acute avian studies, a clear inhibition of food consumption was observed in the mallard duck sub-acute dietary toxicity study. Further discussion of the predicted exposure values relative to the levels at which no mortality and inhibition on food consumption occurred is provided as part of the risk description in **Section 4.2.2.1**.

As shown in **Table 4.3**, chronic avian RQ values based on the highest non-agricultural application rate for saflufenacil of 0.356 lbs a.i./A range from 0.06 to 0.89 and are less than the Agency's chronic LOC of 1.0. Given that chronic RQs based on the highest application rate are less than Agency's LOC, RQs associated with agricultural use patterns at lower application rates would also be less than the chronic LOC. Therefore, risks to birds and the terrestrial-phase amphibians and reptiles for which they serve as surrogates associated with chronic exposure to saflufenacil are expected to be minimal.

Table 4.3. Avian RQs for Chronic Exposure to Saflufenacil Based on a Maximum Application Rate of 0.356 lbs a.i./A.

DIETARY CATEGORY	Chronic RQ
Short Grass	0.89
Tall Grass	0.41
Broadleaf Plants/Small Insects	0.50
Fruits/Pods/Seeds/Large Insects	0.06

4.1.2.2. Mammals

Similar to birds, acute RQs are also not calculated for mammals because only non-definitive acute oral toxicity data are available. Based on the available acute toxicity data, no mortality was observed in any of the mammalian studies at the highest concentrations/doses tested. Further discussion of the predicted exposure values relative to the levels at which no mortality was observed is provided as part of the risk description in **Section 4.2.2.2.**

Based on the highest application rate of 0.356 lbs a.i./A for non-agricultural uses of saflufenacil, RQs calculated for chronic mammalian exposure range from 0.02 to 0.28 for dietary exposure and 0.02 to 2.47 for dose-based RQs using upper 90th percentile Kenaga values (see **Table 4.4**). The RQs for six body-size/dietary categories exceed the Agency's LOC for chronic exposure: 15 g, 35 g, and 1000 g mammals that eat short grass (RQs = 1.13 to 2.47); 15 g and 35 g mammals that eat broadleaf plants/small insects (RQs = 1.19 to 1.39); and 15 g mammals that eat tall grass

(RQ = 1.13). Although dose-based chronic RQs exceed the Agency's LOC for a number of body-size/dietary categories, based on the highest application rate of 0.356 lbs a.i./A for non-agricultural uses, dose-based RQs based on lower application rates of ≤0.134 lbs a.i./A (for all other proposed use patterns) are less than chronic LOCs.

Table 4.4. Mammalian RQs for Chronic Exposure to Saflufenacil				
Dietary Category	**Body Size**	**0.356 lbs a.i./A (non-ag uses)**		**0.134 lbs a.i./A (ag uses)**
		Dietary-based Chronic RQ	**Dose-based Chronic RQ**	**Dose-based Chronic RQ**
Short Grass	15 g	0.28	**2.47**	0.93
	35 g		**2.11**	0.79
	1,000 g		**1.13**	0.43
Tall Grass	15 g	0.13	**1.13**	0.43
	35 g		0.97	0.36
	1,000 g		0.52	0.20
Broadleaf Plants/Small Insects	15 g	0.16	**1.39**	0.52
	35 g		**1.19**	0.45
	1,000 g		0.64	0.24
Fruits/Pods/Seeds/Large Insects	15 g	0.02	0.15	0.06
	35 g		0.13	0.05
	1,000 g		0.07	0.03
Granivore	15 g	N/A	0.03	0.01
	35 g		0.03	0.01
	1,000 g		0.02	0.01

Bolded numbers indicate RQs that exceed the Agency's chronic risk LOC for mammals

4.1.2.2. Terrestrial Invertebrates

Saflufenacil is classified as 'practically non-toxic' to honey bees on an acute contact and oral exposure basis, based on available data for the TGAI and the BAS 800 01H formulated product. In addition, saflufenacil caused no effect to earthworms during 14-days of exposure at the highest test concentration of 1,000 mg a.i./kg dw soil. The estimated concentration of saflufenacil in the top 15-cm of soil, based on the maximum non-agricultural application rate of 0.356 lbs a.i./A, is 0.20 mg a.i./kg soil. Given that the NOAEC value for earthworms is approximately 4 orders of magnitude higher than the maximum estimated soil concentration of saflufenacil, adverse effects to earthworms are unlikely. Additional characterization of the potential risks of saflufenacil to terrestrial invertebrates, including consideration of non-guideline laboratory studies to non-target arthropods, is provided as part of the risk description in **Section 4.2.2.2**.

4.1.2.3. Non-target Terrestrial and Semi-Aquatic Plants

Potential effects to riparian and upland vegetation are assessed using RQs from terrestrial plant seedling emergence and vegetative vigor EC_{25} data as a screen. Based on the results of the submitted terrestrial plant toxicity tests for the two formulated products (BAS 800 01H and BAS 800 02H; see **Table 3.30**), it appears that dicot plants are more sensitive in the vegetative vigor test and monocots are more sensitive in the seedling emergence test. However, the available data indicate that all tested plants, with the exception of wheat and bean exposed to the BAS 800 01H formulation in the seedling emergence test, exhibited adverse effects in the seedling emergence and vegetative vigor tests. The results of these tests indicate that a variety of terrestrial plants that may inhabit riparian and upland zones may be sensitive to saflufenacil exposure.

A summary of the RQs for monocot and dicot terrestrial plants exposed to saflufenacil formulations (at application rates ranging from 0.022 to 0.354 lbs a.i./A) is provided in **Tables 4.5** and **4.6**, respectively. With respect to monocots, all listed and non-listed RQs exceed LOCs with the exception of drift-impacted RQs associated with ground applications at ≤ 0.134 lbs a.i./A and dry area RQs associated with ground application to grape vines. All listed and non-listed RQs for dicots in dry adjacent, semi-aquatic, and drift impacted areas are above LOCs. RQ values are highest for terrestrial plants located in wetland or semi-aquatic areas; non-listed and listed species RQs for plants in wetland areas are 8.01 – 225 and 56.1 – 10,878, respectively, depending on the application rate. Respective non-listed and listed RQ values for terrestrial plants in dry adjacent areas range from 0.94 – 40.9 and 6.6 – 1,978. For areas impacted by drift, all listed species RQs (3.33 – 989) and non-listed species RQs for dicots (2.2 – 178) are above LOCs; non-listed species RQs for monocots are exceeded for all modeled aerial application rates ranging from 0.045 to 0.356 lbs a.i./A and ground applications for only the highest non-agricultural use rate of 0.356 lbs a.i./A. Further discussion of spray drift buffers is included in **Appendix E** and in the risk description for terrestrial plants.

Table 4.5 RQs* for Monocots Inhabiting Dry and Semi-Aquatic Areas Exposed to Saflufenacil via Runoff and Drift

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ[1]	Dry area RQ[1]	Semi-aquatic area RQ[1]
Non-agricultural areas	0.354	Aerial	5	**12.7 (989)**	**25.4 (1,978)**	**140 (10,878)**
		Ground	1	**2.54 (198)**	**15.3 (1,187)**	**130 (10,087)**
Corn, sorghum, fallow, small grains	0.134	Aerial	5	**4.79 (372)**	**9.57 (744)**	**52.6 (4,094)**
		Ground	1	0.96 **(74.4)**	**5.74 (447)**	**48.8 (3,797)**
Soybeans and legumes	0.089	Aerial	5	**3.18 (247)**	**6.36 (464)**	**35.0 (2,719)**
		Ground	1	0.64 **(49.4)**	**3.81 (297)**	**32.4 (2,521)**
Cotton, sunflower, citrus fruit, pome fruit, stone fruit, tree nuts[2]	0.045	Aerial	5	**1.61 (125)**	**3.21 (250)**	**17.7 (1,375)**
		Ground	1	0.32 **(25)**	**1.93 (150)**	**16.4 (1,275)**
Grape vines	0.022	Ground	1	0.16 **(12.2)**	0.94 **(73.3)**	**8.01 (623)**

* = LOC exceedances (RQ ≥ 1) are bolded.
[1] Listed species RQs are provided in parentheses.
[2] Saflufenacil may be applied to citrus fruit, pome fruit, stone fruit, and tree nuts only via ground application.

Table 4.6 RQs* for Dicots Inhabiting Dry and Semi-Aquatic Areas Exposed to Saflufenacil via Runoff and Drift						
Use	**Application rate (lbs a.i./A)**	**Application method**	**Drift Value (%)**	**Spray drift RQ[1]**	**Dry area RQ[1]**	**Semi-aquatic area RQ[1]**
Non-agricultural areas	0.354	Aerial	5	**178 (270)**	**40.9 (178)**	**225 (979)**
		Ground	1	**35.6 (53.9)**	**24.5 (107)**	**207 (908)**
Corn, sorghum, fallow, small grains	0.134	Aerial	5	**67 (102)**	**15.4 (67)**	**84.7 (102)**
		Ground	1	**13.4 (20.3)**	**9.24 (40.2)**	**78.6 (342)**
Soybeans and legumes	0.089	Aerial	5	**44.5 (67.4)**	**10.2 (44.5)**	**56.3 (245)**
		Ground	1	**8.90 (13.5)**	**6.14 (26.7)**	**52.2 (227)**
Cotton, sunflower, citrus fruit, pome fruit, stone fruit, tree nuts[2]	0.045	Aerial	5	**22.5 (34.1)**	**5.17 (22.5)**	**28.5 (124)**
		Ground	1	**4.50 (6.82)**	**3.10 (13.5)**	**26.4 (115)**
Grape vines	0.022	Ground	1	**2.20 (3.33)**	**1.52 (6.60)**	**12.9 (56.1)**

* = LOC exceedances (RQ $\geq$ 1) are bolded
[1] Listed species RQs are provided in parentheses.
[2] Saflufenacil may be applied to citrus fruit, pome fruit, stone fruit, and tree nuts only via ground application

4.2. Risk Description

The results of this baseline-level risk assessment indicate that the proposed uses of saflufenacil have the potential for direct adverse effects on listed and non-listed mammals (based on chronic exposure associated with non-agricultural use patterns) and listed and non-listed terrestrial plants (based on all proposed use patterns). Although risks to aquatic organisms are not predicted based on the screening-level assessment, there is uncertainty associated with this risk conclusion relative to aquatic animals, given that saflufenacil is classified as an LDPH and photo-enhanced toxicity is a possibility. This uncertainty will be addressed as part of the risk description. Based on the results of the baseline-level assessment, the risk hypothesis [*...the proposed saflufenacil uses have the potential to reduce survival, reproduction, and/or growth in terrestrial and aquatic organisms*] is supported. These results are based on the maximum application rates for the proposed saflufenacil uses. Although direct adverse effects to fish, aquatic-phase amphibians, aquatic invertebrates, aquatic plants, birds, terrestrial-phase amphibians, reptiles, and terrestrial invertebrates from saflufenacil use are not expected, indirect effects to all taxa are possible, given the potential for adverse effects to terrestrial plants. Because plants are vital components of most habitats and ecosystems, alterations in the abundance of plants or in the composition of plant communities could result in adverse effects to non-plant species. Potential effects include, but are not limited to, reduction in food resources, decrease in cover (*e.g.*, for predator avoidance), change in water quality parameters (*e.g.*, increases or decreases in temperature and DO), and loss of breeding/nesting habitat.

4.2.1. Risks to Aquatic Animals

Acute and chronic RQs for estuarine/marine invertebrates and freshwater fish/invertebrates, respectively, do not exceed the Agency's LOCs, based on the highest surface water EECs associated with the proposed non-agricultural use pattern for saflufenacil, which are higher than surface water EECs associated with the proposed agricultural use patterns for saflufenacil. With the exception of acute freshwater invertebrate data, where 10% mortality was observed at the limit test concentration, no mortality or sublethal effects were reported at the limit concentrations tested in the available acute freshwater animal and estuarine/marine fish studies.

Although there is potential exposure to aquatic organisms from residues in ground water leachate that provide the baseflow in surface water bodies, the EEC in ground water leachate associated with the proposed non-agricultural use pattern for saflufenacil was an order of magnitude lower than the surface water EECs used in risk estimation. Therefore, potential acute and chronic risks from exposure to residues in baseflow are expected to be minimal and RQs for baseflow were not quantitatively estimated.

Although acute RQs were not derived for freshwater and estuarine/marine fish and freshwater invertebrates, potential acute risks are expected to be minimal because the concentrations at which "no effects" or "<50% effect" were observed for parent saflufenacil (96-hr LC_{50}s range from >98,000 to >108,000 µg a.i./L) are over 16,800x higher than the maximum predicted peak concentration of 5.8 µg a.i./L. Even if 50% mortality/immobility of freshwater/estuarine marine fish and freshwater invertebrates were observed at the lowest limit dose of 98,000 µg a.i./L, the corresponding RQ based on the peak concentration of 5.8 µg a.i./L would be 5.9E-05 and is well below the acute listed species LOC of 0.05. In addition, acute exposure of freshwater fish to saflufenacil is also not expected to result in adverse effects based on the more toxic BAS 781 02H formulation because the 96-hr LC_{50} (17,700 µg formulation/L) and associated NOAEC value of 2,500 µg formulation/L are roughly 3,050x and 430x higher than the peak EEC, and the corresponding acute RQ (5.8 / 17,700) of 0.0003 is approximately two orders of magnitude below the acute risk to listed species LOC. Similarly, acute exposure of freshwater invertebrates to saflufenacil is also not expected to result in adverse effects based on the BAS 781 02H formulation , given that the 48-hr EC_{50} (13,600 µg formulation/L) and associated NOAEC value of 6,500 µg formulation/L are roughly 2,340x and 1,120x higher than the peak EEC, and the corresponding acute RQ (5.8 / 13,600) of 0.0004 is also well below the acute risk to listed species LOC. As previously discussed in **Section 3.3.1**, although the BAS 781 02H formulation is approximately 6-7 times more toxic to freshwater fish and invertebrates than technical grade saflufenacil, the increased toxicity of the formulated product is likely due to the presence of dimethenamid-p, rather than saflufenacil.

Based on the available information, the likelihood of adverse effects on freshwater and estuarine/marine invertebrates due to acute and chronic exposure of saflufenacil is considered low for the proposed uses. In addition, acute exposure to saflufenacil is not expected to result in adverse effects to freshwater and estuarine/marine fish. Although saflufenacil may be more toxic to aquatic taxa in the presence of light, the available data indicate that LDPHs impact the viability of the egg cell membrane surrounding embryos. In addition, it is also possible that conditions akin to porphyria, such as hematologic effects, may also occur in fish and other aquatic taxa. Therefore, the potential for increased toxicity via chronic routes of exposure and associated early life-stage endpoints for aquatic animals are examined below in **Section 4.2.1.1.**

4.2.1.1. Potential for Light-Enhanced Phototoxicity

Saflufenacil is a LDPH chemical and may be more toxic under conditions of natural sunlight than in standard laboratory lighting (Matringe, 1989). Although the Agency has proposed testing this class of compounds under UV light conditions (EFED, 2007), such data are not available for saflufenacil. Based on fathead minnow early-life cycle tests submitted for oxyfluorfen, another chemical in this class, UV light conditions appear to increase toxicity by approximately 29-fold (MRID 46585104), as compared to fish early-life cycle studies with the same chemical under normal laboratory lighting conditions. To evaluate the effect of increased toxicity, fish ELS toxicity endpoints were adjusted by a factor of 29, and RQs were recalculated based on the highest EEC associated with the non-agricultural use pattern for saflufenacil. Based on an adjusted fish chronic toxicity endpoint of 34.4 µg a.i./L (997 µg a.i./L / 29) and the highest 60-day EEC based on non-agricultural uses of saflufenacil (5.2 µg a.i./L), the adjusted chronic RQ value is 0.15, well below the chronic risk LOC of 1.0. In order for the chronic risk LOC to be exceeded, the fish ELS NOAEC would have to be ≤ 5.2 µg a.i./L or approximately 6.6 times lower than the adjusted NOAEC value of 34.4 µg a.i./L (or 191x lower than the NOAEC from the study conducted under normal laboratory lighting). Based on the effects observed in the oxyfluorfen study (decreased hatching time and reduced larval survival) and the mode of action for LDPHs, it is likely that oxyfluorfen may have affected the integrity of the egg cell membrane surrounding the embryo, resulting in premature hatching. Disruption of the egg cell membrane may have occurred via an accumulation of porphyrins resulting in free radicals that cause oxidative damage to the egg cell. Given this observed effect, extrapolation of the enhanced toxicity to fish at early life stages following prolonged exposure to toxicity endpoints from acute toxicity tests was judged to be inappropriate. Tests conducted under UV lighting conditions are not available for aquatic invertebrates; therefore, the type and magnitude of potential phototoxic effects on these types of organisms is unknown. Given that many zooplankton have translucent bodies and are present in the surface layers of water bodies where UV rays can more readily penetrate (Barron *et al.*, 2000, Diamond *et al.*, 2005), photoenhanced toxicity to these taxa is a possibility. Although chronic risks to aquatic vertebrates based on an assumed enhanced phototoxicity for saflufenacil are expected to be minimal based on estimated exposure values at the maximum application rate, there is uncertainty associated with the 29x toxicity adjustment factor derived from the limited data for oxyfluorfen. As previously discussed in **Section 3.3.2.1**, the lighting intensity in the oxyfluorfen modified light ELS study was lower than is typically measured in the environment. In addition, variability between replicates occurred within treatment groups where effects were observed suggesting that light exposure may have been uneven between replicates, possibly confounding toxicity expression. Aside from uncertainties associated with the oxyfluorfen modified light ELS study, it is expected that variability in species sensitivity would occur in the environment versus species commonly tested in the laboratory. Furthermore, spatial and temporal variability in the potential for toxicity enhancement are likely to differ substantially between the laboratory and the field, depending on the interaction and variability of UV exposure with the timing and location of reproduction and hatching events in the natural environment. In addition, it is possible that organisms may have compensatory mechanisms to protect again UV radiation that would limit the extent of photo-enhanced toxicity.

In summary, chronic risks associated with exposure to saflufenacil are expected to be minimal for fish and aquatic-phase amphibians based on an interim enhanced toxicity adjustment factor of 29x to account for potential enhanced phototoxicity. However, if the results of the surrogate LPPH modified light ELS testing indicate the potential for enhanced toxicity ≥ 191 times of that observed under standard laboratory lighting, the conclusions of this assessment relative to chronic risk for fish would need to be revisited. In addition, although risks to aquatic animals are expected to be low, indirect effects to aquatic animals based on direct impacts to terrestrial plants, including riparian vegetation, are possible.

4.2.1. Risks to Aquatic Plants

Risks to vascular and non-vascular aquatic plants are expected to be minimal because all listed and non-listed species RQs are less than LOCs, based on the highest peak aquatic EEC for saflufenacil non-agricultural use patterns. Although risks to aquatic vascular and non-vascular are not anticipated, the potential for indirect effects is possible via direct effects to terrestrial plant species, including riparian vegetation.

4.2.2. Risks to Terrestrial Organisms

4.2.2.1. Birds

The avian chronic risk LOC is not exceeded for any of the proposed saflufenacil use patterns, indicating that the likelihood of adverse effects on birds, terrestrial-phase amphibians, and reptiles due to chronic exposure is low. Because there was no mortality or sublethal effects at the highest treatment levels tested in the submitted acute oral and sub-acute dietary avian studies, standard RQs values for acute and sub-acute exposure were not calculated in the Risk Estimation section of this assessment. However, food consumption was inhibited in the mallard duck sub-acute dietary study at the highest test concentration of 5,270 mg/kg-diet with no effect reported at 2,023 mg a.i./kg-diet. In order to gain a better understanding of how the EECs for the maximum proposed saflufenacil application rate relate to the toxicity data currently available for birds, T-REX was used to calculate RQs using the conservative assumption that the highest value in the avian acute oral study (*i.e.*, acute LD_{50} = 2,000 mg a.i./kg-bw) and the NOAEC value for the avian sub-acute dietary study (*i.e.*, acute LC_{50} = 2,023 mg a.i./kg-diet) represent the avian acute endpoints. The resulting dose-based and dietary-based acute RQs for all size and dietary classes, based on the upper bound Kenaga values ranged from 0 to 0.09, less than the acute risk to avian listed species LOC of 0.1. In actuality, these RQs would be much lower than the estimated values because no effects were identified at the 2,000 mg a.i./kg-bw and 2,023 mg a.i./kg-diet levels. Therefore, direct risk to birds (and to terrestrial-phase amphibian and reptiles for which birds serve as surrogates) from acute, sub-acute, or chronic exposure to saflufenacil is expected to be low. However, given the potential for effects on terrestrial plant species associated with the use of saflufenacil, indirect effects to birds are possible.

As previously discussed in **Section 3.3.2.1**, avian acute oral data are now required for passerine species, as well as either waterfowl or upland game species. Given that no acute oral passerine data are available for saflufenacil, a characterization of the potential for passerine effects, based on dose-based exposures and data available for other avian species, is completed. As shown in **Table 3.8**, dose-based exposures for 20 g birds exposed to the maximum application rate for saflufenacil of 0.356 lbs a.i./A range from 6.1 to 97 mg a.i./kg-bw. Assuming that passerines are of equal sensitivity to acute dose-based exposures of saflufenacil as the bobwhite quail and mallard duck, risks would not be expected because no avian mortalities were observed at the maximum dose level of 2,000 mg a.i./kg-bw. Given that no mortality was observed at the highest treatment level in either submitted acute oral study for mallard duck or bobwhite quail, it is unclear how much more sensitive passerine species would have to be as compared with waterfowl and upland game species to exceed LOCs. However, the LD_{50} for passerine species would have to be at least 1.4x lower than the highest treatment level tested for waterfowl and upland game species to exceed the acute avian listed species LOC. Submittal of a protocol and subsequent data for the acute oral passerine toxicity study in accordance with OPPTS 850.2100 would reduce the uncertainty associated with risks to passerines.

4.2.2.2. Mammals

Acute RQs were not derived for mammals in the Risk Estimation section of this assessment because no mortality was observed at the highest treatment level in the acute oral mammalian studies for saflufenacil. Assuming that the highest treatment level tested in the acute mammalian studies is representative of the acute mammalian endpoint (*i.e.*, acute LC_{50} = 2,000 mg a.i/kg bw), acute RQs derived using upper bound Kenega values in T-REX were ≤0.02 for all size and dietary classes and are below the acute risk LOCs for mammals. Therefore, direct risk to mammals from acute exposure to saflufenacil is low.

Based on the highest application rate of 0.356 lbs a.i./A for non-agricultural use patterns, the Agency's chronic risk LOC is exceeded for the following six body size/dietary categories: 15g, 35g, and 1000g mammals eating short grass, 15g and 35g mammals eating broadleaf plants/small insects, and 15g mammals eating tall grass (RQs that exceed the LOC range from 1.13 to 2.47). Chronic risk LOC exceedances were based a reproductive NOAEL of 15 mg a.i./kg bw/day. Increased stillborn pups, increased pup mortality during the early phases of lactation, reduced pup weight, and anemia were observed at a treatment level of 50 mg a.i./kg bw/day. It is possible that the observed effects associated with mammalian anemia may be associated with accumulated porphyrins; however, the extent to which this effect may be present or enhanced in wild mammals due to UV light exposure is unknown. Although chronic risk LOC is exceeded for a number of mammalian body size and dietary categories, based on the maximum saflufenacil application rate of 0.356 lbs a.i./A for non-agricultural uses, chronic RQs associated with application rates ≤0.143 lbs a.i./A are less than the chronic risk LOC of 1.0. Based on T-REX, the highest chronic RQ for effects to mammals from chronic exposure to saflufenacil at 0.143 lbs a.i./A is 0.99 for 15g mammals eating short grass (see **Appendix C; Table C.2**). Therefore, potential risks to listed and non-listed mammals based on chronic exposure to saflufenacil at 0.356 lbs a.i./A are possible; however, risks are not expected at application rates ≤0.134 lbs a.i./A. Although risks to mammals are not expected at application rates ≤0.134 lbs a.i./A, the potential for indirect effects to mammals, based on direct effects to terrestrial plants, exists.

4.2.2.3. Terrestrial Invertebrates

The available toxicity data for honey bees indicate that direct contact and oral exposure to saflufenacil is not likely to result in adverse effects to beneficial terrestrial invertebrates such as pollinators in and around the use areas for the proposed uses of saflufenacil. In addition, no adverse effects were observed in earthworms exposed to saflufenacil at 1000 mg a.i./kg dw soil. Assuming a soil depth of 15cm, the expected concentration of saflufenacil in soil at the maximum application rate of 0.356 lbs a.i./A is 0.203 mg/kg soil. The predicted maximum concentration of saflufenacil in soil is approximately 4,900x lower than the concentration at which no effects to earthworms were observed; therefore, direct exposure to saflufenacil in the soil is not likely to result in adverse effects for earthworms.

As previously discussed in **Section 3.3.2.3**, non-guideline toxicity data with BAS 800 01H (70% saflufenacil) and BAS 781 02H (6.24% saflufenacil) formulations are also available for two sensitive standard arthropod species, including the parasitic wasp (*Aphidius rhopalosiphi*) and predatory mite (*Typhlodromus pyri*). The reported BAS 800 01H LR_{50} values for parasitic wasp and predatory mite of 0.51 lbs a.i./A and 0.40 lbs a.i./A, respectively, are approximately 3 to 4 times higher than the maximum application rate of 0.134 lbs a.i./A for this formulated product; therefore, risks associated with exposure to the BAS 800 01H formulation are expected to minimal. BAS 781 02H is proposed for use at a maximum rate of 0.134 lbs a.i./A. Available acute toxicity data for this formulation on the parasitic wasp and predatory mite report 48-hour LR_{50} values of 0.001 lbs a.i./A and 0.015 lbs a.i./A, respectively. Given that 50% mortality of the parasitic wasp and predatory mite was observed at exposure concentrations ranging from 9 to 134 times less than the maximum application rate of 0.134 lbs a.i./A, it is possible that the use of BAS 781 02H on corn and sorghum may adversely affect sensitive arthropod species. Other than parasitic wasp and predatory mite data, there are no other data on the toxicity of the BAS 781 02H formulation to other terrestrial invertebrates or pollinators. Terrestrial invertebrate toxicity data for dimethenamid-p active ingredient in the BAS 781 02H formulation are not available; therefore, it is not possible to determine whether the toxicity of BAS 781 02H is due to dimethenamid-p rather than saflufenacil. Based on the available data, risk for direct adverse effects to terrestrial invertebrates is considered low for saflufenacil and all formulations, with the exception of BAS 781 02H. It is possible that risks to terrestrial invertebrates, including beneficial insects, may occur based on exposure to the BAS 781 02H formulated product, which is used on field corn, sweet corn, popcorn, and grain sorghum. Submittal of a honeybee acute contact toxicity study for the BAS 781 02H formulation, completed in accordance with OPPTS 850.3020 would reduce the uncertainty associated with the observed toxicity of this formulation to sensitive arthropod species.

In addition, the potential for indirect effects to terrestrial invertebrates from saflufenacil use cannot be discounted, due to the risk to terrestrial plants.

4.2.2.3. Terrestrial Plants

Tier II plant studies demonstrate the potential for saflufenacil to affect terrestrial plants. As shown in **Table 4.5**, RQs exceed non-listed LOCs for monocots inhabiting dry and semi-aquatic areas exposed to saflufenacil via runoff and drift for aerial and ground applications at 0.354 lbs a.i./A and aerial applications for all other use patterns ranging from 0.045 to 0.134 lbs a.i./A; risk to listed species LOCs are also exceeded for monocots, based on all modeled use patterns and application rates. Additionally, risk to listed and non-listed species LOCs are exceeded for dicots (**Table 4.6**), based on all proposed saflufenacil use patterns. In general, it appears that dicots are more sensitive to spray drift than monocots; drift RQs are approximately 14x higher for dicots than monocots. Dicots also appear slightly more sensitive to exposures in dry and semi-aquatic areas with RQ values that are approximately 1.6x higher than those for monocots. Further examination of the terrestrial plant species sensitivity to saflufenacil shows that all 10 tested species of monocots and dicots, with the exception of wheat and beans tested with the BAS 800 01H formulation, show phytotoxicity to saflufenacil at maximum application rates. In addition, it should be noted that there may be concern for more sensitive plant species or cultivars, given that certain EECs associated with the non-agricultural use pattern are very close to the maximum application rates. For example, the EEC associated with loading to semi-aquatic areas from aerial applications to non-agricultural areas is approximately 56% of the maximum application rate of 0.354 lbs a.i./A.

In order to further explore the sensitivity of terrestrial plants to the two saflufenacil formulations, refined RQs were derived separately for each formulation, considering the formulation-specific toxicity endpoints and maximum single application rates. The BAS 800 01H formulation is applied to orchards (*i.e.*, citrus fruit, pome fruit, stone fruit, and tree nuts) via the ground at a maximum single application rate of 0.045 lbs a.i./A; the BAS 800 02H formulation is applied to non-agricultural areas via ground or aerial methods at a maximum application rate of 0.356 lbs a.i./A. As shown in **Tables 4.7** and **4.8**, all RQs exceed LOCs with the exception of non-listed monocot drift RQs and non-listed dicot dry area RQs for the BAS 800 01H formulation. Comparison of RQs for both formulations based on ground applications shows that RQ values are generally higher for non-listed species exposed to the BAS 800 02H formulation; the same trend is also observed for listed species, with the exception of dry and semi-aquatic area RQs based on ground applications of BAS 800 01H.

Table 4.7. Comparison of RQ Values for Terrestrial and Semi-Aquatic Monocots Exposed to the BAS 800 01H and BAS 800 02H Formulations.

Taxa	Application Method	Dry Area RQ		Semi-aquatic Area RQ		Drift RQ	
		BAS 800 01H[1]	BAS 800 02H[2]	BAS 800 01H[1]	BAS 800 02H[2]	BAS 800 01H[1]	BAS 800 02H[2]
Nonlisted Species	Ground	**1.93**	**3.45**	**16.4**	**29.3**	0.32	**1.19**
	Aerial	NA	**5.74**	NA	**31.6**	NA	**5.93**
Listed Species	Ground	**150**	**1.68**	**1275**	**14.3**	**25**	**1.78**
	Aerial	**NA**	**2.80**	**NA**	**15.4**	**NA**	**8.90**

[1] RQs based on BAS 800 01H maximum single application rate of 0.045 lbs a.i./A via ground applications only.
[2] RQs based on BAS 800 02H maximum single application rate of 0.356 lbs a.i./A via aerial and ground applications.
Bolded numbers indicate RQs that exceed the Agency's LOC for plants.

Table 4.8. Comparison of RQ Values for Terrestrial and Semi-Aquatic Dicots Exposed to the BAS 800 01H and BAS 800 02H Formulations.							
Taxa	Application Method	Dry Area RQ		Semi-aquatic Area RQ		Drift RQ	
		BAS 800 01H[1]	BAS 800 02H[2]	BAS 800 01H[1]	BAS 800 02H[2]	BAS 800 01H[1]	BAS 800 02H[2]
Nonlisted Species	Ground	0.87	**24.6**	**7.40**	**209**	**2.37**	**35.6**
	Aerial	NA	**40.9**	NA	**225**	NA	**178**
Listed Species	Ground	**1.73**	**107**	**14.7**	**908**	**2.81**	**53.9**
	Aerial	NA	**178**	NA	**979**	NA	**270**

[1] RQs based on BAS 800 01H maximum single application rate of 0.045 lbs a.i./A via ground applications only.
[2] RQs based on BAS 800 02H maximum single application rate of 0.356 lbs a.i./A via aerial and ground applications.
Bolded numbers indicate RQs that exceed the Agency's LOC for plants.

Given that RQ values, based on spray drift at application rates of 0.022 to 0.354 lbs a.i./A, are in excess of LOCs for terrestrial plants, the AgDRIFT model (Version 2.01) was used to refine the spray drift exposure estimate. Downwind spray drift buffers were evaluated to determine the distance required to dissipate spray drift to below the LOC, based on both NOAEC and EC_{25} levels for terrestrial plants. Dissipation to the no effect and EC_{25} level was modeled in order to provide potential buffer distances that are protective of listed and non-listed terrestrial plant species, respectively. Because the distance of the spray drift buffer is dependent on the maximum application rate associated with the intended use patterns for saflufenacil, drift buffers were derived for all proposed use patterns and associated application rates. A summary of the results of the AgDRIFT modeling is presented in **Table 4.9**; further details are presented in **Appendix E**. Details concerning the specifics and uncertainties associated with the AgDRIFT model are available online at www.agdrift.com.

Table 4-9. Summary of AgDRIFT Modeling Results for Listed and Non-Listed Plant Species By Use Pattern				
Use (Application Rate)	Dissipation Distance for Ground Application (ft)		Dissipation Distance for Aerial Applications (ft)	
	Listed Plants	Non-listed Plants	Listed Plants	Non-listed Plants
Non-agricultural areas (0.356 lbs a.i./A)	>1,000	502 - >1,000	>5,280	2,926 - >5,280
Corn, sorghum, fallow, small grains (0.134 lbs a.i./A)	>1,000	62 - >1,000	>5,280	1,188 - >5,280
Soybeans and legumes (0.089 lbs a.i./A)	>1,000	157 - >1,000	>5,280	629 – 4,984
Cotton and sunflower (0.045 lbs a.i./A)	961 - >1,000	82 - 748	4,400 - >5,280	302 – 3,763
Fruits and tree nuts (0.045 lbs a.i./A)	961 - >1,000	82 - 748	NA	NA
Grape vines (0.022 lbs a.i./A)	607 - >1,000	69 - 453	NA	NA

The results of the AgDRIFT modeling show that drift dissipation distances, based on ground boom applications are expected to exceed the 1,000 foot limit of the AgDRIFT ground model for listed plants (based on all use patterns) and non-listed plants (for use patterns ≥ 0.089 lbs a.i./A). Spray drift buffers ranging from 69 to 748 feet would be needed to protect non-listed plants from ground applications of saflufenacil ≤0.045 lbs a.i./A. Modeled dissipations distances for listed plants, based on aerial application of all proposed uses of saflufenacil (≥0.045 lbs a.i./A), exceed the 1 mile limit of the Tier III aerial AgDRIFT model. Spray drift buffers for non-listed plants also exceed the 1 mile limit, based on aerial applications of saflufenacil at rates ≥0.134 lbs a.i./A, and range from 303 to 4,984 feet for rates ≤0.089 lbs a.i./A. The predicted dissipation distances for listed plant species (for all use patterns) and for non-listed species (for ground applications ≥0.089 lbs a.i./A and aerial applications ≥0.134 lbs a.i./A) are uncertain because they exceed the reliable limits of the AgDRIFT model. Although the exact dissipation distances are uncertain, there is potential for adverse effects of saflufenacil use to listed and non-listed monocot and dicot plants that extend well beyond the intended treatment site for both ground and aerial applications. Furthermore, the results of this analysis indicate that risk to listed species of plants cannot be reasonably mitigated for aerial and ground applications.

5. Federally Threatened and Endangered (Listed) Species Concerns

Section 7 of the Endangered Species Act, 16 U.S.C. Section 1536(a)(2), requires all federal agencies to consult with the National Marine Fisheries Service (NMFS) for marine and anadromous listed species, and/or the United States Fish and Wildlife Service (USFWS) for listed wildlife and freshwater organisms, if they are proposing an "action" that may affect listed species or their designated critical habitat. Each federal agency is required under the Act to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. To jeopardize the continued existence of a listed species means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species" (50 C.F.R. § 402.02).

To facilitate compliance with the requirements of the Endangered Species Act (subsection (a)(2)), the Office of Pesticide Programs has established procedures to evaluate whether a proposed registration action may directly or indirectly appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of any listed species (USEPA, 2004). After the Agency's screening level risk assessment is conducted, if any of the Agency's listed species LOCs are exceeded for either direct or indirect effects, an analysis is conducted to determine if any listed or candidate species may co-occur in the area of the proposed pesticide use or areas downstream or downwind that could be contaminated from drift or runoff/erosion. If listed or candidate species may be present in the proposed action area, further biological assessment is undertaken. The extent to which listed species may be at risk is considered, which then determines the need for the development of a more comprehensive consultation package, as required by the Endangered Species Act.

The federal action addressed herein is the proposed new registration of saflufenacil on agricultural and non-agricultural use sites. Given that saflufenacil can be used on both agricultural and non-agricultural areas, it is expected that its use could occur nationwide.

5.1. Action Area

For listed species assessment purposes, the action area is considered to be the area affected directly or indirectly by saflufenacil use and not merely the immediate area where saflufenacil is applied. At the initial screening-level, the risk assessment considers broadly described taxonomic groups and conservatively assumes that listed species within those broad groups are co-located with the pesticide treatment area. This means that listed terrestrial plants and wildlife are assumed to be located on or adjacent to the treated site and listed aquatic organisms are assumed to be located in a surface water body adjacent to the treated site. The assessment also assumes that the listed species are located within an assumed area, which has the relatively highest potential exposure to the pesticide, and that exposures are likely to decrease with distance from the treatment area. **Section 3.1** of this risk assessment presents the proposed pesticide use sites that are used to establish initial co-location of species with treatment areas.

5.2. Taxonomic Groups Potentially at Risk

If the assumptions associated with the screening-level action area result in RQs that are below the listed species LOCs, a "no effect" determination conclusion is made with respect to listed species in that taxa, and no further refinement of the action area is necessary. Furthermore, RQs below the listed species LOCs for a given taxonomic group indicate no concern for indirect effects on listed species that depend upon the taxonomic group for which the RQ was calculated. However, in situations where the screening assumptions lead to RQs in excess of the listed species LOCs for a given taxonomic group, a potential for a "may affect" conclusion exists and may be associated with direct effects on listed species belonging to that taxonomic group or may extend to indirect effects upon listed species that depend upon that taxonomic group as a resource. In such cases, additional information on the biology of listed species, the locations of these species, and the locations of use sites are considered to determine the extent to which screening assumptions regarding an action area apply to a particular listed organism. These subsequent refinement steps will consider how this information would impact the action area for a particular listed organism and potentially include areas of exposure that are downwind and downstream of the pesticide use site.

Assessment endpoints, exposure pathways, and the conceptual models addressing proposed new saflufenacil uses, and the associated exposure and effects analyses conducted for the saflufenacil screening-level risk assessment are in **Sections 2 to 3**. The assessment endpoints used in the screening-level risk assessment include those defined operationally as reduced survival and reproductive impairment for both aquatic and terrestrial animal species and survival, reproduction, and growth of aquatic and terrestrial plant species from both direct acute and chronic exposures. These assessment endpoints are intended to address the standard set forth in the Endangered Species Act requiring federal agencies to ensure that any action they authorize does not appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species. Risk estimates (RQs) which, integrating exposure and effects, are calculated for broad based taxonomic groups in the screening-level risk assessment presented in **Section 4.**

Both acute endangered species and chronic risk LOCs are considered in the screening-level risk assessment to identify direct and indirect effects to taxa of listed species. This section identifies direct effect concerns, by taxa, that are triggered by exceeding endangered LOCs in the screening-level risk assessment, with an evaluation of the potential probability of individual effects for exposures that may occur at the established endangered species LOC. Data on exposure and effects collected under field and laboratory conditions are evaluated to make determinations on the predictive utility of the direct effect screening assessment findings to listed species. Additionally, the results of the screen for indirect effects to listed species, using direct effect acute and chronic LOCs for each taxonomic group, is presented and evaluated.

Table 5.1. Potential Effects to Federally Listed Taxa Associated with Direct or Indirect Effects from the Proposed New Uses of Saflufenacil.

Listed Taxon	Direct Effects	Uses of Concern	Indirect Effects	Uses of Concern
Terrestrial and semi-aquatic plants - monocots	Yes	All uses	Yes[2]	Non-agricultural
Terrestrial and semi-aquatic plants - dicots	Yes	All uses	Yes[2]	Non-agricultural
Terrestrial invertebrates	No	None	Yes[1,2]	All uses
Birds	No	None	Yes[1,2]	All uses
Terrestrial-phase amphibians	No	None	Yes[1,2]	All uses
Reptiles	No	None	Yes[1,2]	All uses
Mammals	Yes	Non-agricultural	Yes[1]	All uses
Aquatic vascular plants	No	None	Yes[1]	All uses
Freshwater fish	No	None	Yes[1]	All uses
Aquatic-phase amphibians	No	None	Yes[1]	All uses
Freshwater invertebrates	Yes[a]	Corn and grain sorghum	Yes[1]	All uses
Mollusks	No	None	Yes[1]	All uses
Marine/estuarine fish	No	None	Yes[1]	All uses
Marine/estuarine invertebrates	No	None	Yes[1]	All uses

[a] Risks associated with exposure to BAS 781 02H formulation only.
Potential indirect effects on a taxon attributable to:
[1] direct effects on terrestrial monocot and dicot plants
2 direct chronic effects on mammals

5.2.1. Probit Dose-Response Analysis

The Agency uses the probit dose-response relationship as a tool for providing additional information on the potential for acute direct effects to individual listed species and aquatic animals that may indirectly affect the listed species of concern (USEPA, 2004). As part of this evaluation, the acute RQ for listed species is presented in terms of the chance of an individual event (*i.e.*, mortality or immobilization) should exposure at the EEC actually occur for a species with sensitivity to saflufenacil on par with the acute toxicity endpoint selected for RQ calculation. To accomplish this interpretation, the Agency uses the slope of the dose-response relationship available from the toxicity study used to establish the acute toxicity measures of effect for each taxonomic group that is relevant to this assessment. The individual effects probability associated with the acute RQ is based on the mean estimate of the slope and an assumption of a probit dose-response relationship. In addition to a single effects probability estimate based on the mean, upper and lower estimates of the effects probability are also provided to account for variance in the slope, if available. Based on the available acute toxicity for saflufenacil, a summary of the probit dose-response analysis is provided in **Table 5.2**. If no dose response information is available to estimate a slope for this analysis, a default slope assumption of 4.5 (with lower and upper bounds of 2 to 9) (Urban and Cook, 1986) is used.

Individual effect probabilities are calculated based on an Excel spreadsheet tool IECV1.1 (Individual Effect Chance Model Version 1.1) developed by the U.S. EPA, OPP, Environmental Fate and Effects Division (June 22, 2004). The model allows for such calculations by entering the mean slope estimate (and the 95% confidence bounds of that estimate) as the slope parameter for the spreadsheet. The desired threshold for the probability of an individual effect is entered as the listed species LOC. In addition, the probability of an individual effect is also derived based on the calculated acute RQ, if available.

Table 5.2. Summary of Saflufenacil Probit Dose Response Analysis for Listed Species

Taxa (study type)	Acute Effect Slope (95% C.I.)	Chance of Individual Effect at Listed Species LOC (95% C.I.)	Chance of Individual Effect at Derived Acute RQ[1] (95% C.I.)
Bird oral dose	No mortality observed	Not calculated; no mortality observed	Not calculated; no mortality observed
Bird dietary	No mortality observed	Not calculated; no mortality observed	Not calculated; no mortality observed
Mammal oral dose	No mortality observed	Not calculated; no mortality observed	Not calculated; no mortality observed
Freshwater fish	No mortality observed	Not calculated; no mortality observed	Not calculated; no mortality observed
Freshwater invertebrate	10% Immobilization/mortality Slope NA = 4.5 (2 – 9)	Not calculated[2]	Not calculated[2]
Estuarine/marine fish	No mortality observed	Not calculated; no mortality observed	Not calculated; no mortality observed
Estuarine/marine invertebrate	Mortality Slope = 2.51 (1.28 – 3.73)	1 in 1,830 (1 in 20.9 to 1 in 1.64E+06)	1 in 8.34E+14 (1 in 3.71E+04 to 1 in 3.50E+31)

[1] Acute RQ for estuarine/marine invertebrates = 0.0007.
[2] RQs were not derived because concentrations at which <50% effect were observed are well above the peak saflufenacil concentration of 5.8 μg/L.

As shown in **Table 5.2**, the probability for acute direct effects (*i.e.*, mortality) to individual listed estuarine/marine invertebrates at the listed species LOC is 1 in 1,830 (0.05%). However, at the highest derived RQ value for the proposed new uses of saflufenacil, the chance of an individual effect to estuarine/marine invertebrates decreases to approximately 1 in 8.34E+14 (1.2E-13%). The chance of an individual effect was not derived for taxa other than estuarine/marine invertebrates because either no mortality was observed in acute studies or "<50% effect levels" were well above estimated peak concentrations of saflufenacil. In summary, the chance of individual effects to listed species is low at the LOC and even lower for RQs derived based on the maximum application rate EECs.

5.2.2. Listed Species Occurrence Associated with Saflufenacil Use

The goal of the co-location analysis is determine whether sites of pesticide use are geographically associated with known locations of listed species [following the convention of the Services, the word 'species' in this assessment may apply to a 'species', 'subspecies', or an Evolutionary Significant Unit (ESU)]. At the screening level, this analysis is accomplished using the LOCATES database (version 2.10.3). The database uses location information for listed species at the county level and compares it to agricultural census data (from 2002) for crop production at the same county level of resolution. The product is a listing of Federally-listed species that are located in counties known to produce the crops upon which the pesticide will be used.

Non-agricultural use patterns for saflufenacil represent the highest application rate for this herbicide, and all taxa that rely on terrestrial plants and/or mammals for some stage of their life-cycle may be indirectly affected. Therefore, all listed species occurring nationwide may potentially be affected by the proposed new registration of saflufenacil. Because there is a potential for indirect effects to all listed taxa and non-agricultural uses of saflufenacil (which correspond to the maximum application rate for this chemical) may occur anywhere in the United States or its territories, state and county-level summaries from LOCATES are not provided. However, a summary of listed species that may be directly or indirectly affected by the proposed new uses of saflufenacil is provided in **Appendix F**. Based the results of the LOCATES database query, there are a total of 1,153 listed species from all taxa associated with counties where saflufenacil may potentially be used nationwide for non-agricultural purposes.

This preliminary analysis indicates that there is a potential for saflufenacil use to overlap with listed species and that a more refined assessment is warranted. The more refined assessment should involve clear delineation of the action area associated with proposed uses of saflufenacil and the best available information on the temporal and spatial co-location of listed species with respect to the action area. This analysis has not been conducted for this assessment.

6. References

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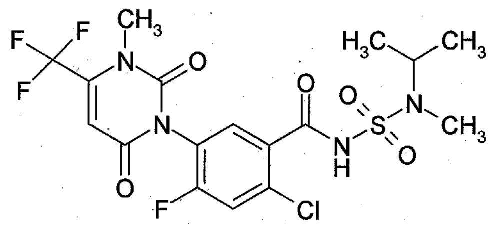
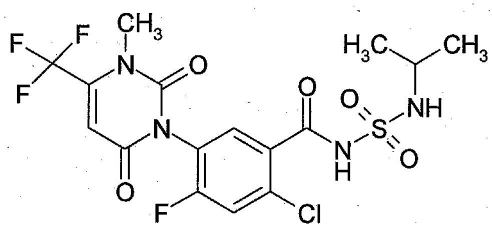
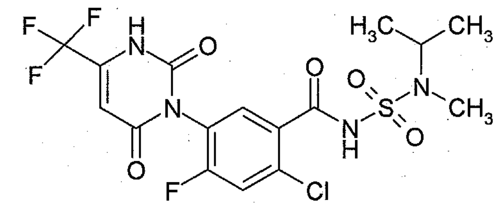
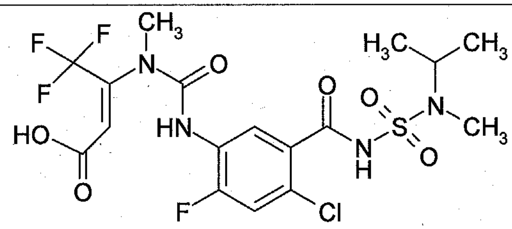
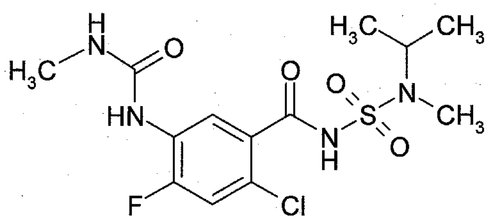
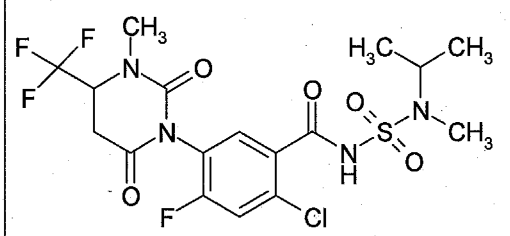
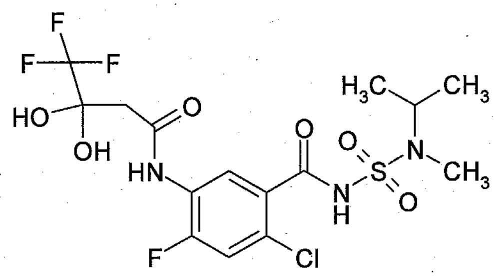
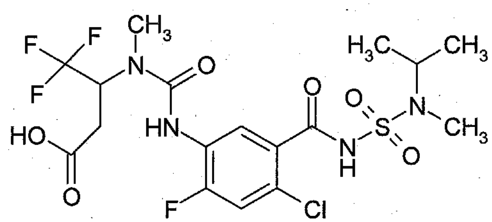
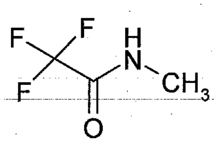
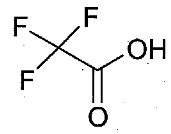
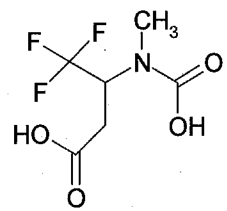
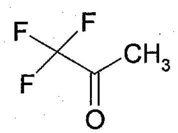
Appendix A. Chemical Names, Structures, and Maximum Reported Amounts of Saflufenacil and Its Degradates.

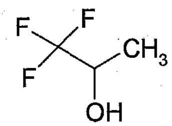
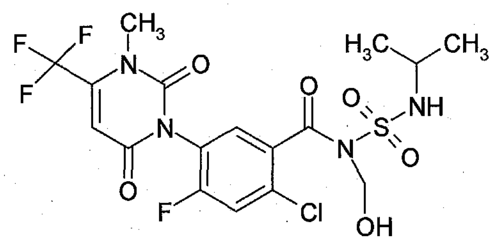
Table A-1. Saflufenacil and Its Major Organic Environmental Degradates.

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	Maximum %AR (day)	Final %AR (study length)
		PARENT			
Saflufenacil BAS 800 H	**IUPAC:** N'-{2-Chloro-4-fluoro-5-[1,2,3,6-tetrahydro-3-methyl-2,6-dioxo-4-(trifluoromethyl)pyrimidin-1-yl]benzoyl}-N-isopropyl-N-methylsulfamide **CAS:** 2-Chloro-5-[3,6-dihydro-3-methyl-2,6-dioxo-4-(trifluoromethyl)-1(2H)-pyrimidinyl]-4-fluoro-N-[[methyl(1-methylethyl)amino] sulfonyl]benzamide **CAS-no:** 372137-35-4 **Formula:** $C_{17}H_{17}ClF_4N_4O_5S$ **MW:** 500.86 g/mol				
		MAJOR (>10%) TRANSFORMATION PRODUCTS			
M01 M800H01	N'-[2-Chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-(trifluoromethyl)-3,6-dihydro-1(2H)-pyrimidinyl)benzoyl]-N'-isopropylsulfamide **Formula:** $C_{16}H_{15}ClF_4N_4O_5S$ **MW:** 486.83 g/mol		Aerobic soil	**10** (57)	1.3 (330)
			Anaerobic soil	**14** (-3, 34)	10 (75)
			Soil photolysis	5.4 (14)	nd[1] (30)
			Aqueous photolysis	not detected	
			Hydrolysis	not identified	
			Aerobic aquatic	not detected	
			Anaerobic aquatic	not identified	
			Field studies	0.02 ppm (0-8, 11, 20)	nd[1] (124, 271, 360)

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	Maximum %AR (day)	Final %AR (study length)
M02 **M800H02**	N'-[2-Chloro-5-(2,6-dioxo-4-(trifluoromethyl)-3,6-dihydro-1(2H)-pyrimidinyl)-4-fluorobenzoyl]-N-isopropyl-N-methylsulfamide **Formula:** $C_{16}H_{15}ClF_4N_4O_5S$ **MW:** 486.83 g/mol		Aerobic soil	**30** (246)	17 (330)
			Anaerobic soil	**24** (75)	24 (75)
			Soil photolysis	not detected	
			Aqueous photolysis	not detected	
			Hydrolysis	not identified	
			Aerobic aquatic	not detected	
			Anaerobic aquatic	not identified	
			Field studies	0.01 ppm (0-2, 6)	nd[1] (360)
M04 **M800H04**	**Formula:** $C_{17}H_{19}ClF_4N_4O_6S$ **MW:** 518.87 g/mol		Aerobic soil	not identified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aq. photolysis -pH5 Aq. photolysis -pH7	4.1 (20) 5.4 (10)	4.1 (20) 1.8 (21)
			Hydrolysis -pH7 Hydrolysis -pH9	0.95 (30) **13** (3)	0.95 (30) nd[1] (30)
			Aerobic aquatic	not identified	
			Anaerobic water Anaerobic sediment Anaerobic system	4.4 (62) 0.5 (62) 4.4 (62)	nd[1] (364) nd[1] (364) nd[1] (364)
			Field studies	not analyzed	
M07 **M800H07**	N-{4-Chloro-2-fluoro-5-[({[isopropyl (methyl) amino] sulfonyl} amino) carbonyl] phenyl}-N'-methylurea **Formula:** $C_{13}H_{18}ClFN_4O_4S$ **MW:** 380.83 g/mol		Aerobic soil	**52** (25)	7.2 (330)
			Anaerobic soil	4.4 (60)	1.5 (75)
			Soil photolysis	**19** (14)	2.3 (30)
			Aq. photolysis -pH5 Aq. photolysis -pH7	8.6 (20) 9.5 (15)	8.6 (20) 8.2 (21)
			Hydrolysis –pH7 Hydrolysis –pH9	9.2 (30) 77 (30)	9.2 (30) 77 (30)
			Aerobic water Aerobic sediment Aerobic system	**20** (30) 3.7 (60) **23** (60)	19 (60) 3.7 (60) 23 (60)
			Anaerobic water Anaerobic sediment Anaerobic system	**62** (364) **13** (91) **71** (91)	62 (364) 6.7 (364) 68 (364)
			Field studies	0.02 ppm (11, 20, 44)	nd[1] (124, 271)

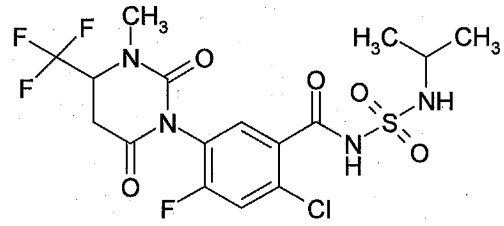
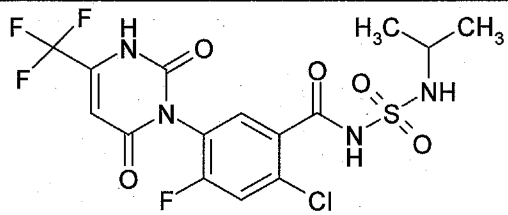
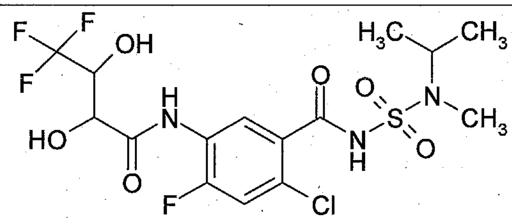
Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	Maximum %AR (day)	Final %AR (study length)
M08 M800H08	N'-[2-Chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-(trifluoromethyl) tetrahydro-1(2H)-pyrimidinyl) benzoyl]-N-isopropyl-N-methylsulfamide **Formula:** $C_{17}H_{19}ClF_4N_4O_5S$ **MW:** 502.88 g/mol		Aerobic soil	**66** (246)	41 (330)
			Anaerobic soil	**25** (18)	18 (75)
			Soil photolysis	**19** (22)	18 (30)
			Aqueous photolysis	not detected	
			Hydrolysis	not identified	
			Aerobic aquatic	not detected	
			Anaerobic aquatic	not identified	
			Field studies	0.05 ppm (1, 6)	nd[1] (124, 360)
M15 M800H15	N-{4-Chloro-2-fluoro-5-[({[isopropyl (methyl) amino] sulfonyl} amino) carbonyl] phenyl}-4-4-4-trifluoro-3,3-dihydroxybutanamide **Formula:** $C_{15}H_{18}ClF_4N_3O_6S$ **MW:** 479.84 g/mol		Aerobic soil	not identified	
			Anaerobic soil	1.6 (18)	nd[1] (75)
			Soil photolysis	9.6 (30)	9.6 (30)
			Aq. photolysis -pH5 Aq. photolysis -pH7	2.3 (20) 1.3 (10)	2.3 (20) nd[1] (21)
			Hydrolysis –pH7 Hydrolysis –pH9	2.3 (30) **22** (30)	2.3 (30) 22 (30)
			Aerobic aquatic	not detected	
			Anaerobic water Anaerobic sediment Anaerobic system	**17** (62-91) 0.9 (273) **17** (62-91)	7.1 (364) 0.8 (364) 7.6 (364)
			Field studies	not detected	
M22 M800H22	3-[({4-Chloro-2-fluoro-5-[({[isopropyl(methyl)amino]sulfonyl}amino)carbonyl]anilino}carbonyl)(methyl)amino]-4,4,4-trifluorobutanoic acid **Formula:** $C_{17}H_{21}ClF_4N_4O_6S$ **MW:** 520.89 g/mol		Aerobic soil	**16** (43)	7.1 (334)
			Anaerobic soil	1.6 (60)	0.2 (75)
			Soil photolysis	not detected	
			Aqueous photolysis	not detected	
			Hydrolysis	not identified	
			Aerobic aquatic	not detected	
			Anaerobic aquatic	not identified	
			Field studies	not detected	
M26 M800H26	N-Methyl-2,2,2-trifluoroacetamide **Formula:** $C_3H_4F_3NO$ **MW:** 127.07 g/mol		Aerobic soil	**18** (25)	nd[1] (334)
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	

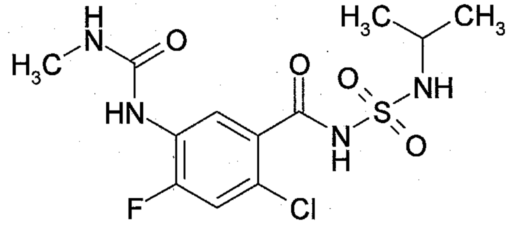
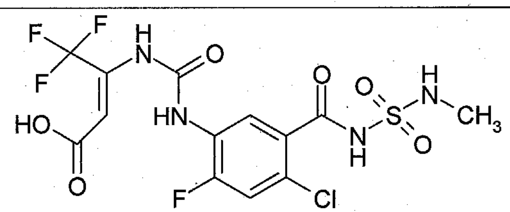
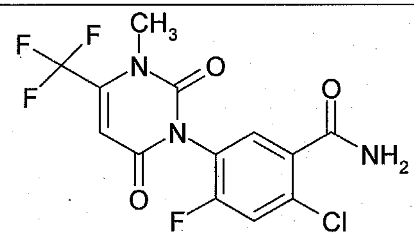
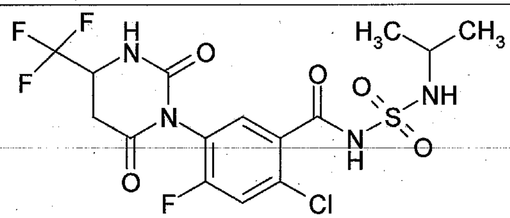
Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	Maximum %AR (day)	Final %AR (study length)
M29 M800H29 TFA (also formulated as TFA, sodium salt)	Trifluoroacetic acid **Formula:** $C_2HF_3O_2$ **MW:** 114.02 g/mol		Aerobic soil	not identified but not quantified	
			Anaerobic soil	6.9 (0)	3.7 (75)
			Soil photolysis	not identified	
			Aq. photolysis -pH5	4.0 (20)	4.0 (20)
			Aq. photolysis -pH7	**29** (21)	29 (21)
			Hydrolysis	not identified	
			Aerobic water	6.9 (60)	6.9 (60)
			Aerobic sediment	2.0 (51-60)	2.0 (60)
			Aerobic system	8.8 (60)	8.8 (60)
			Anaerobic water	9.2 (364)	9.2 (364)
			Anaerobic sediment	3.6 (91)	1.9 (364)
			Anaerobic system	**11** (364)	11 (364)
			Field studies	not analyzed	
M31 M800H31	3-[Carboxy(methyl)amino]-4,4,4-trifluorobutanoic acid **Formula:** $C_6H_8F_3NO_4$ **MW:** 215.13 g/mol		Aerobic soil	**18** (43)	8.7 (334)
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	
M33 M800H33	1,1,1-Trifluoroacetone **CAS-no:** 421-50-1 **Formula:** $C_3H_3F_3O$ **MW:** 112.05 g/mol		Aerobic soil	not identified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aq. photolysis -pH5	3.2 (20)	3.2 (20)
			Aq. photolysis -pH7	**20** (15)	17 (21)
			Hydrolysis –pH7	4.7 (30)	4.7 (30)
			Hydrolysis –pH9	**74** (21)	73 (30)
			Aerobic water	**23** (7)	3.2 (60)
			Aerobic sediment	nd[1]	nd[1]
			Aerobic system	**23** (7)	3.2 (60)
			Anaerobic water	**15** (62)	nd[1] (364)
			Anaerobic sediment	0.9 (62)	nd[1] (364)
			Anaerobic volatiles	**13** (160-364)	13 (364)
			Anaerobic system	**25** (62)	13 (364)
			Field studies	not analyzed	

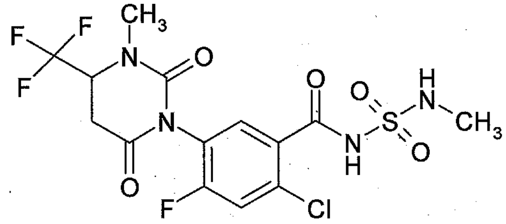
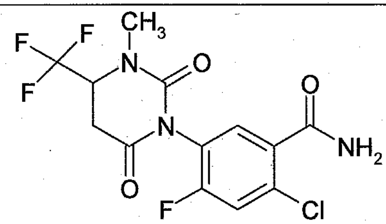
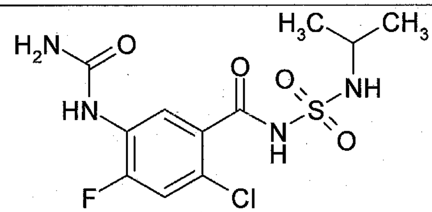
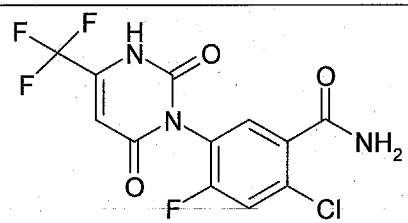
Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	Maximum %AR (day)	Final %AR (study length)
TFP	1,1,1-Trifluoro-2-propanol **CAS-no:** 374-01-6 **Formula:** $C_3H_5F_3O$ **MW:** 114.07 g/mol		Aerobic soil	not identified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic water	**16** (62)	0.4 (364)
			Anaerobic sediment	3.4 (62)	nd[1] (364)
			Anaerobic volatiles	**24** (160-364)	24 (364)
			Anaerobic system	**30** (62)	24 (364)
			Field studies	not analyzed	
Product 8	**Formula:** $C_{17}H_{15}ClF_4N_4O_6S$ **MW:** 516.86 g/mol		Aerobic soil	not identified	
			Anaerobic soil	not identified	
			Soil photolysis	**17** (15)	17 (15)
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	
Unknown 3/2/2	Unknown compound with t_R 3.9 min that formed under irradiated conditions in the aqueous photolysis study, including unknowns 2 (phenyl-labeled) in the pH5 study and unknowns 3 (phenyl-labeled) and 2 (uracil-labeled) in the pH7 study.	Unknown	Aq. photolysis -pH5	1.0 (20)	1.0 (20)
			Aq. photolysis -pH7	**9.5** (21)	9.5 (21)

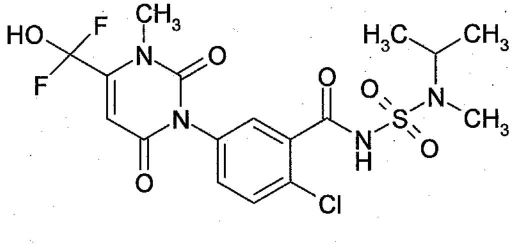
1 "nd" means that the compound was not detected.

Table A-2. Minor Organic Environmental Degradates of Saflufenacil.

Code	Chemical name	Chemical structure	Study Type	Maximum %AR (day)	Final %AR (study length)
M06 M800H06	N-[2-Chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-(trifluoromethyl)tetrahydro-1(2H)-pyrimidinyl)benzoyl]-N'-isopropylsulfamide **Formula:** $C_{16}H_{17}ClF_4N_4O_5S$ **MW:** 488.85 g/mol		Aerobic soil	identified but not quantified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	
M11 M800H11	N'-[2-Chloro-5-(2,6-dioxo-4-(trifluoromethyl)-3,6-dihydro-1(2H)-pyrimidinyl)-4-fluorobenzoyl]-N-isopropylsulfamide **Formula:** $C_{15}H_{13}ClF_4N_4O_5S$ **MW:** 472.81 g/mol		Aerobic soil	not analyzed	
			Anaerobic soil	not identified	
			Soil photolysis	not analyzed	
			Aqueous photolysis	not analyzed	
			Hydrolysis	not analyzed	
			Aerobic aquatic	not detected	
			Anaerobic aquatic	not analyzed	
			Field studies	not analyzed	
M16 M800H18	2-Chloro-4-fluoro-N-{isopropyl (methyl)-amino] sulfonyl}-5-[(4,4,4-trifluoro-2,3-dihydroxybutanyl) amino] benzamide **Formula:** $C_{15}H_{18}ClF_4N_3O_6S$ **MW:** 479.84 g/mol		Aerobic soil	not identified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic water Anaerobic sediment Anaerobic system	8.4 (364) 0.9 (273-364) 9.3 (364)	8.4 (364) 0.9 (364) 9.3 (364)
			Field studies	not analyzed	

Code	Chemical name	Chemical structure	Study Type	Maximum %AR (day)	Final %AR (study length)
M18 M800H18	2-Chloro-4-fluoro-N-[(isopropylamino) sulfmony]-5-{[(methylamino) carbonyl] amino} benzamide **Formula:** $C_{12}H_{16}ClFN_4O_4S$ **MW:** 366.80 g/mol		Aerobic soil	not identified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic water	6.2 (273)	6.0 (364)
			Anaerobic sediment	0.9 (364)	0.9 (364)
			Anaerobic system	7.0 (273)	6.7 (364)
			Field studies	not analyzed	
M24 M800H24	(2E)-3-({[4-Chloro-2-fluoro-5-({[(methylamino)sulfonyl] amino}carbonyl)aniline]carbonyl}amino)-4,4,4-trifluoro-2-butenoic acid **Formula:** $C_{13}H_{11}ClF_4N_4O_6S$ **MW:** 462.77 g/mol		Aerobic soil	identified but not quantified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	
M25 M800H25	2-Chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-(trifluoromethyl)-3,6-dihydro-1(2H)-pyrimidinyl)benzamide **Formula:** $C_{13}H_8ClF_4N_3O_3$ **MW:** 365.67 g/mol		Aerobic soil	identified but not quantified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aq. photolysis -pH5	2.9 (20)	2.9 (20)
			Aq. photolysis -pH7	1.8 (15)	1.3 (21)
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	
M27 M800H27	N-[2-Chloro-5-(2,6-dioxo-4-(trifluoromethyl)tetrahydro-1(2H)-pyrimidinyl)-4-fluorobenzoyl]-N'-isopropylsulfamide **Formula:** $C_{15}H_{15}ClF_4N_4O_5S$ **MW:** 474.82 g/mol		Aerobic soil	identified but not quantified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	

Code	Chemical name	Chemical structure	Study Type	Maximum %AR (day)	Final %AR (study length)
M28 **M800H28**	N-[2-Chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-(trifluoromethyl)tetrahydro-1(2H)-pyrimidinyl)benzoyl]-N'-methylsulfamide **Formula:** $C_{14}H_{13}ClF_4N_4O_5S$ **MW:** 460.79 g/mol		Aerobic soil	identified but not quantified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	
M30 **M800H30**	2-Chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-(trifluoromethyl)tetrahydro-1(2H)-pyrimidinyl)benzamide **Formula:** $C_{13}H_{10}ClF_4N_3O_3$ **MW:** 367.69 g/mol		Aerobic soil	identified but not quantified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	
M35 **M800H35**	N-[4-Chloro-2-fluoro-5-({[(isopropylamino) sulfonyl] amino} carbonyl) phenyl] urea **Formula:** $C_{11}H_{14}ClFN_4O_4S$ **MW:** 352.77 g/mol		Aerobic soil	identified but not quantified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not detected	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	
Product 3	2-Chloro-5-[2,6-dioxo-4-(trifluoromethyl)-3,6-dihydropyrimidin-1(2H)-yl]-4-fluorobenzamide **Formula:** $C_{12}H_6ClF_4N_3O_3$ **MW:** 351.65		Aerobic soil	not identified	
			Anaerobic soil	not identified	
			Soil photolysis	9.2 (30)	9.2 (30)
			Aqueous photolysis	not identified	
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	

Code	Chemical name	Chemical structure	Study Type	Maximum %AR (day)	Final %AR (study length)
Hydroxyl methyl degradate	2-Chloro-5[4-difluoro(hydroxyl) methyl]-(3-methyl-2,6-dioxo-3,6-dihydropyrimidin-1(2H)-yl-N-{[isopropyl(methyl)amino]sulfonyl} benzamide **Formula:** $C_{17}H_{19}ClF_2N_4O_6S$ **MW:** 480.88 g/mol		Aerobic soil	not identified	
			Anaerobic soil	not identified	
			Soil photolysis	not identified	
			Aq. photolysis -pH5	5.3 (10)	2.5 (20)
			Aq. photolysis -pH7	3.3 (15)	1.0 (21)
			Hydrolysis	not identified	
			Aerobic aquatic	not identified	
			Anaerobic aquatic	not identified	
			Field studies	not analyzed	

Appendix B. Aquatic Model Input/Output Data.

Table B-1. Summary of Input/Output Files.

File name	Date	Location/Simulation
Input/Output File for SCI-GROW		
Saf-eco.sci	Apr. 15, 2009	National screen
Input Files for PRZM/EXAMS		
CArigh.pzr	Apr. 16, 2009	Non-agricultural areas
Crop Scenario Files for PRZM/EXAMS		
CArightofwayRLF_V2.txt	Mar. 26, 2008	California rights-of-way
Weather Data Files for PRZM/EXAMS		
W23234.dvf	Jul. 3, 2002	San Francisco, CA

Example Input/Output Data for Individual Simulations

SCI-GROW Input/Output File.

```
SciGrow version 2.3
chemical:Saflufenacil
time is  4/15/2009  18:25:37
-------------------------------------------------------------------
 Application    Number of     Total Use    Koc     Soil Aerobic
 rate (lb/acre) applications  (lb/acre/yr) (ml/g)  metabolism (days)
-------------------------------------------------------------------
    0.356         1.0         0.356     1.00E+01     25.0
-------------------------------------------------------------------
groundwater screening cond (ppb) =   3.56E-01
************************************************************************
```

PRZM/EXAMS Example Input/Output File.

```
stored as CArigh.out
Chemical: Saflufenacil
PRZM environment: CArightofwayRLF_V2.txt          modified Wedday, 26 March 2008 at 09:38:28
EXAMS environment: pond298.exv          modified Thuday, 29 August 2002 at 16:33:30
Metfile: w23234.dvf     modified Wedday, 3 July 2002 at 09:04:22
Water segment concentrations (ppb)

Year            Peak     96 hr    21 Day   60 Day   90 Day   Yearly
1961            2.119    2.099    2.038    1.627    1.391    0.3483
1962            8.553    8.488    8.158    7.469    6.629    2.433
1963            5.914    5.867    5.671    5.244    4.939    3.353
1964            3.013    2.983    2.877    2.648    2.341    1.673
```

1965	2.352	2.334	2.252	2.034	1.906	1.489
1966	2.667	2.643	2.562	2.347	2.05	1.364
1967	2.192	2.173	2.098	1.939	1.828	1.382
1968	1.399	1.386	1.329	1.239	1.173	0.8841
1969	2.781	2.753	2.636	2.418	2.182	0.9773
1970	1.941	1.924	1.856	1.711	1.609	1.241
1971	1.411	1.397	1.342	1.279	1.244	0.9178
1972	6.502	6.451	6.191	5.659	5.109	1.749
1973	4.507	4.47	4.318	3.993	3.764	2.664
1974	2.282	2.263	2.187	2.026	1.911	1.394
1975	5.054	5.003	4.802	4.414	4.011	1.566
1976	3.483	3.454	3.337	3.088	2.913	2.248
1977	2.441	2.422	2.341	2.167	2.044	1.472
1978	1.408	1.394	1.336	1.26	1.246	0.9193
1979	2.794	2.765	2.663	2.446	2.186	1.048
1980	2.064	2.046	1.975	1.822	1.715	1.285
1981	1.852	1.834	1.769	1.637	1.557	1.106
1982	3.903	3.863	3.724	3.422	2.869	1.34
1983	2.893	2.869	2.771	2.561	2.412	1.688
1984	4.504	4.458	4.273	3.976	3.614	1.531
1985	3.194	3.168	3.062	2.836	2.675	2.002
1986	2.112	2.094	2.019	1.861	1.75	1.255
1987	1.836	1.817	1.745	1.612	1.495	0.8556
1988	1.492	1.477	1.417	1.342	1.273	0.9194
1989	4.058	4.017	3.851	3.572	3.001	1.213
1990	3.036	3.011	2.905	2.685	2.532	1.721

Sorted results

Prob.	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.032258064516129	8.553	8.488	8.158	7.469	6.629	3.353
0.0645161290322581	6.502	6.451	6.191	5.659	5.109	2.664
0.0967741935483871	5.914	5.867	5.671	5.244	4.939	2.433
0.129032258064516	5.054	5.003	4.802	4.414	4.011	2.248
0.161290322580645	4.507	4.47	4.318	3.993	3.764	2.002
0.193548387096774	4.504	4.458	4.273	3.976	3.614	1.749
0.225806451612903	4.058	4.017	3.851	3.572	3.001	1.721
0.258064516129032	3.903	3.863	3.724	3.422	2.913	1.688
0.290322580645161	3.483	3.454	3.337	3.088	2.869	1.673
0.32258064516129	3.194	3.168	3.062	2.836	2.675	1.566
0.354838709677419	3.036	3.011	2.905	2.685	2.532	1.531
0.387096774193548	3.013	2.983	2.877	2.648	2.412	1.489
0.419354838709677	2.893	2.869	2.771	2.561	2.341	1.472
0.451612903225806	2.794	2.765	2.663	2.446	2.186	1.394
0.483870967741936	2.781	2.753	2.636	2.418	2.182	1.382
0.516129032258065	2.667	2.643	2.562	2.347	2.05	1.364
0.548387096774194	2.441	2.422	2.341	2.167	2.044	1.34
0.580645161290323	2.352	2.334	2.252	2.034	1.911	1.285
0.612903225806452	2.282	2.263	2.187	2.026	1.906	1.255
0.645161290322581	2.192	2.173	2.098	1.939	1.828	1.241
0.67741935483871	2.119	2.099	2.038	1.861	1.75	1.213
0.709677419354839	2.112	2.094	2.019	1.822	1.715	1.106
0.741935483870968	2.064	2.046	1.975	1.711	1.609	1.048
0.774193548387097	1.941	1.924	1.856	1.637	1.557	0.9773
0.806451612903226	1.852	1.834	1.769	1.627	1.495	0.9194
0.838709677419355	1.836	1.817	1.745	1.612	1.391	0.9193

0.870967741935484	1.492	1.477	1.417	1.342	1.273	0.9178
0.903225806451613	1.411	1.397	1.342	1.279	1.246	0.8841
0.935483870967742	1.408	1.394	1.336	1.26	1.244	0.8556
0.967741935483871	1.399	1.386	1.329	1.239	1.173	0.3483
0.1	5.828	5.7806	5.5841	5.161	4.8462	2.4145
			Average of yearly averages:			1.46796

Inputs generated by pe5.pl - Novemeber 2006

Data used for this run:
Output File: CArigh

Metfile:	w23234.dvf			
PRZM scenario:	CArightofwayRLF_V2.txt			
EXAMS environment file:	pond298.exv			
Chemical Name:	Saflufenacil			
Description	Variable Name	Value	Units	Comments
Molecular weight	mwt	501	g/mol	
Henry's Law Const.	henry	4.0e-20	atm-m^3/mol	
Vapor Pressure	vapr		torr	
Solubility	sol	2.1e3	mg/L	
Kd	Kd		mg/L	
Koc	Koc	29.8	mg/L	
Photolysis half-life	kdp	56	days	Half-life
Aerobic Aquatic Metabolism	kbacw	212	days	Halfife
Anaerobic Aquatic Metabolism	kbacs	88	days	Halfife
Aerobic Soil Metabolism	asm	31	days	Halfife
Hydrolysis:	pH 7	248	days	Half-life
Method:	CAM	2	integer	See PRZM manual
Incorporation Depth:	DEPI		cm	
Application Rate:	TAPP	0.400	kg/ha	
Application Efficiency:	APPEFF	0.95	fraction	
Spray Drift	DRFT	0.05	fraction of application rate applied to pond	
Application Date	Date	01-10	dd/mm or dd/mmm or dd-mm or dd-mmm	
Record 17:	FILTRA			
	IPSCND	1		
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC	0.5		
Flag for Index Res. Run	IR	EPA Pond		
Flag for runoff calc.	RUNOFF	none	none, monthly or total(average of entire run)	

Appendix C. Example T-REX Output for Saflufenacil.

Table C.1. Dose- and Dietary-based Upper Bound Kenaga EECs and Chronic RQs Based on the Proposed Use of Saflufenacil for Non-Agricultural Areas (0.356 lbs a.i./A) (Acute RQs were not calculated [NC] because non-definitive toxicity endpoints exist for birds and mammals)

Table C.1a. Upper Bound Kenaga, Chronic Avian Dietary Based Risk Quotients								
NOAEC (ppm)	EECs and RQs							
	Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
96	85.44	0.89	39.16	0.41	48.06	0.50	5.34	0.06

Table C.1b. Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients								
NOAEC (ppm)	EECs and RQs							
	Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
300	85.44	0.28	39.16	0.13	48.06	0.16	5.34	0.02

Size class not used for dietary risk quotients

Table C.1c. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients												
Size Class (grams)	Adjusted NOAEL	EECs and RQs										
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	32.97	81.46	2.47	37.34	1.13	45.82	1.39	5.09	0.15	1.13	0.03
35	26.67	56.30	2.11	25.80	0.97	31.67	1.19	3.52	0.13	0.78	0.03
1000	11.54	13.05	1.13	5.98	0.52	7.34	0.64	0.82	0.07	0.18	0.02

Table C.2. Dose-based Mammalian Chronic RQs Based on Back-calculated Application Rate of 0.143 lbs a.i./A

Table C.2. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients

Size Class (grams)	Adjusted NOAEL	EECs and RQs									
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	32.97	32.72	0.99	15.00	0.45	18.41	0.56	2.05	0.06	0.45	0.01
35	26.67	22.61	0.85	10.37	0.39	12.72	0.48	1.41	0.05	0.31	0.01
1000	11.54	5.24	0.45	2.40	0.21	2.95	0.26	0.33	0.03	0.07	0.01

Appendix D. Example Terrplant (v. 1.2.1) Input and Output for Saflufenacil.

Table D.1. Chemical Identity.	
Chemical Name	**Saflufenacil**
PC code	**118203**
Use	**Non-agricutural**
Application Method	**Aerial**
Application Form	**spray**
Solubility in Water (ppm)	**2100**

Table D.2. Input parameters used to derive EECs.			
Input Parameter	**Symbol**	**Value**	**Units**
Application Rate	A	**0.356**	**lbs ai/A**
Incorporation	I	**1**	none
Runoff Fraction	R	**0.05**	none
Drift Fraction	D	**0.05**	none

Table D.3. EECs for Saflufenacil. Units in lbs ai/A.		
Description	**Equation**	**EEC**
Runoff to dry areas	(A/I)*R	0.0178
Runoff to semi-aquatic areas	(A/I)*R*10	0.178
Spray drift	**A*D**	**0.0178**
Total for dry areas	**((A/I)*R)+(A*D)**	**0.0356**
Total for semi-aquatic areas	**((A/I)*R*10)+(A*D)**	**0.1958**

Table 4. Plant survival and growth data used for RQ derivation. Units are in lbs ai/A.				
	Seedling Emergence		**Vegetative Vigor**	
Plant type	**EC_{25}**	**NOAEC**	**EC_{25}**	**NOAEC**
Monocot	**0.0014**	**0.000018**	**0.003**	**0.002**
Dicot	**0.00087**	**0.0002**	**0.0001**	**0.000066**

Table 5. RQ values for plants in dry and semi-aquatic areas exposed to Saflufenacil through runoff and/or spray drift.*				
Plant Type	**Listed Status**	**Dry**	**Semi-Aquatic**	**Spray Drift**
Monocot	non-listed	25.43	139.86	12.71
Monocot	listed	1977.78	10877.78	988.89
Dicot	non-listed	40.92	225.06	178.00
Dicot	listed	178.00	979.00	269.70
*If RQ > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.				

Appendix E. AgDRIFT Modeling Approach and Results.

The AgDRIFT model (Version 2.01) was used to refine the spray drift exposure estimate for terrestrial plants. Downwind spray drift buffers were developed for possible use in mitigating risks for listed terrestrial plants that grow in close proximity to agricultural and non-agricultural fields that may be treated with liquid spray applications of saflufenacil. The model was used to estimate spray drift buffer distances for ground and aerial application to reach the NOAEC and EC_{25} doses for the most sensitive monocot and dicot species in the seedling emergence and vegetative vigor studies. The standard toxicity level used for calculating risk quotients for non-listed terrestrial plants is the EC_{25} value. For listed plants, the NOAEC (or EC_{05} if a NOAEC value is not available) is used. Seedling emergence endpoints are representative of exposure through soil to germinating plants, while vegetative vigor endpoints are representative of foliar exposure. The most sensitive terrestrial monocot and dicot measurement endpoints and the associated fraction of the application rate for the maximum non-agricultural use rate of 0.356 lbs a.i./A are specified in **Table E.1**. Because the distance of the spray drift buffer is dependent on the maximum application rate associated with the label and intended use patterns for saflufenacil, drift buffers were derived for use patterns and application rates specified in **Table E.2**.

Table E.1. AgDRIFT Input Parameters for Terrestrial Plant Measurement Endpoints for

Test Type / Crop	Most Sensitive Study Species	NOAEC (lbs a.i./A) / Fraction Applied[1]	EC_{25} (lbs a.i./A) / Fraction Applied[1]	Most Sensitive Parameter
Seedling Emergence: Monocot	Onion	0.000018 / 0.00005	0.0014 / 0.0039	Seedling Emergence
Vegetative Vigor: Dicot	Tomato	0.000066 / 0.00019	0.0001 / 0.00028	Dry weight

[1] The fraction of the application rate = NOAEC or the EC25 / maximum application rate of saflufenacil (0.356 lbs a.i./A).

Table E.2. Modeled Use Patterns, Application Rates, Application Methods, and Applied Rate Fractions

Use	Single Max Application Rate (lbs a.i./A)	Method of Application	Fraction of EC_{25} Applied[1]		Fraction of NOAEC[1] Applied	
			Monocots	Dicots	Monocots	Dicots
Non-agricultural areas	0.354	Ground and aerial	0.0039	0.00028	0.00005	0.00019
Corn, sorghum, fallow, small grains	0.134	Ground and aerial	0.0104	0.0007	0.0001	0.0005
Soybeans and legumes	0.089	Ground and aerial	0.0157	0.0011	0.0002	0.0007
Cotton and Sunflower	0.045	Ground and aerial	0.0311	0.0022	0.0004	0.0015
Fruits and tree nuts	0.045	Ground	0.0311	0.0022	0.0004	0.0015
Grape vines	0.022	Ground	0.0636	0.0045	0.0008	0.0030

[1] Monocot EC_{25} = 0.0014 lbs a.i./A (based on onion SE in SE test); dicot EC_{25} = 0.0001 lbs a.i./A (based on tomato dry weight in VV test)
[2] Monoct NOAEC = 0.000018 lbs a.i./A (based on onion SE in SE test); dicot NOAEC = 0.000066 lbs a.i./A (based on tomato dry weight in VV test)

A summary of the results of the AgDRIFT modeling for ground and aerial application of saflufenacil for all proposed uses and application rates is presented in **Table E.3**. Downwind spray drift buffers or distances required to dissipate spray drift to NOAEC and EC_{25} levels are estimated for listed and non-listed terrestrial plant species, respectively, for ground and aerial applications of saflufenacil. Dissipation at the no effect level was modeled in order to provide potential buffer distances that are protective of listed terrestrial plant species. Dissipation distances to the EC_{25} level were also modeled in order to provide potential buffer distances required to protect non-listed terrestrial plant species. The range of dissipation distances is dependant on a differences in sensitivity between monocot and dicot species. Further details on the AgDRIFT modeling for ground and aerial applications of saflufenacil are provided below.

Table E.3. Summary of AgDRIFT Modeling Results for Listed and Non-Listed Plant Species By Use Pattern

Use (Application Rate)	Dissipation Distance for Ground Application (ft)		Dissipation Distance for Aerial Applications (ft)	
	Listed Plants	Non-listed Plants	Listed Plants	Non-listed Plants
Non-agricultural areas (0.356 lbs a.i./A)	>1,000	502 - >1,000	>5,280	2,926 - >5,280
Corn, sorghum, fallow, small grains (0.134 lbs a.i./A)	>1,000	62 - >1,000	>5,280	1,188 - >5,280
Soybeans and legumes (0.089 lbs a.i./A)	>1,000	157 - >1,000	>5,280	629 - 4,984
Cotton and sunflower (0.045 lbs a.i./A)	961 - >1,000	82 - 748	4,400 - >5,280	302 - 3,763
Fruits and tree nuts (0.045 lbs a.i./A)	961 - >1,000	82 - 748	NA	NA
Grape vines (0.022 lbs a.i./A)	607 - >1,000	69 - 453	NA	NA

Ground Application

The most important factors affecting drift from ground boom applications are spray quality (droplet size), release height, and wind speed. The ground boom part of AgDRIFT is based on field trial data from bare ground applications. The results of the model reflect the quality and conditions of the data on which it was based. The data from field trials were grouped into categories by spray quality (droplet size) and release height. Results from field trials conducted with different wind speeds were averaged. The average wind speed over all trials was approximately 10 mph. Although the saflufenacil labels indicate that drift potential is lowest between wind speeds of 3 to 10 mph, no wind speed is specified; therefore, a 10 mph wind speed was assumed for the purposes of modeling. AgDRIFT outputs for ground boom applications estimate 50^{th} and 90^{th} percentile of data collected from field trials. For this analysis, the 90^{th} percentile was used to provide protective dissipation distances.

The labels for saflufenacil specify the maximum release or application height at 10 feet above the largest plants. Because the specified application height is 10 feet above the canopy, the maximum available release height available in the Tier I ground model of AgDRIFT (high boom release height of 4 feet) is assumed. In addition, both fine and medium/coarse spray droplet sizes were modeled. With the exception of the BAS 781 02H formulation, no droplet size is specified on any of the proposed saflufenacil labels; therefore, the default ASAE droplet size of "very fine to fine" spray is assumed for most use patterns. Because the BAS 781 02H label specifies a droplet size of "medium-to-coarse" or "very coarse" droplets for ground applications, both "very fine and fine" and "fine to medium/coarse" droplet sizes are assumed for use patterns associated with this formulation (*i.e.*, corn and sorghum). The output of AgDRIFT model provides distances (in feet) required to dissipate spray drift to the NOAEC and EC_{25} elvels. Buffer distances are provided for the most sensitive monocot and dicot species (**Table E.1**). The results of the AgDRIFT modeling for ground applications of saflufenacil are provided in **Table E.4**.

Table E.4. Results of AgDRIFT Modeling for Ground Applications of Saflufenacil				
Use (Application Rate)	**Dissipation Distance (ft)**			
	Listed Plants		**Non-listed Plants**	
	Monocots	**Dicots**	**Monocots**	**Dicots**
Non-agricultural areas (0.354 lbs a.i./A)	>1,000	>1,000	502	>1,000
Corn, sorghum, fallow, small grains (0.134 lbs a.i./A)	>1,000	>1,000	62 – 230[1]	>1,000
Soybeans and legumes (0.089 lbs a.i./A)	>1,000	>1,000	157	>1,000
Cotton, sunflower, fruits, and tree nuts (0.045 lbs a.i./A)	>1,000	961	82	748
Grape vines (0.022 lbs a.i./A)	>1,000	607	69	453

[1] A range of dissipation distances is provided for corn and sorghum based on "very fine to fine" and "fine to medium/coarse" drop size distributions. The lower end of the range is intended to be representative of spray drift distances associated with applications of the BAS 781 02H formulation to corn and sorghum.

The results of the AgDRIFT modeling for ground application of saflufenacil show that buffer distances greater than 1,000 feet would be required to dissipate spray drift to NOAEC levels for all modeled use patterns, with the exception of cotton, sunflower, fruits, tree nuts, and grape vines. Spray drift distances that are protective of listed dicots based on ground application of saflufenacil for these use patterns ($\leq$0.045 lbs a.i./A) range from 607 to 961 feet. Although it is not possible to derive an exact buffer distance that would be protective of listed monocot plants (for all use patterns) and listed dicot plants (for use patterns with application rates $\geq$0.089 lbs a.i./A), spray drift can be reduced by lowering the release height and/or increasing the spray droplet size. For non-listed monocots, the range of protective spray drift buffers is 62 to 502 feet; for non-listed dicots, the range is 453 to >1,000 feet.

Aerial Application

The most important factors affecting drift from aerial applications are spray droplet size, release height, and wind speed. The aerial part of the AgDRIFT model predicts mean dissipation distances based on the inputs provided. When wind speed and/or release height is lower than the modeled values, the spray drift levels would be expected to be lower. Conversely, in instances where applications may be made in higher wind speeds or at a higher release height, these inputs may be adequately conservative and higher tier modeling may be necessary.

Although the labels for saflufenacil do not specify a droplet size for aerial applications, fixed wing applications (applications made by airplanes) are limited in the coarsest droplet size that can be sprayed. Typical fixed wing aerial application speeds exceed 120 mph. At these speeds, coarse droplets shatter and produce medium or finer sprays. Thus, it is generally inappropriate to model coarse sprays for fixed wing applications without some restriction.

For aerial applications, the AgDRIFT model contains three tiers of increasing complexity. The Tier III aerial modeling was used to determine the dissipation distance to NOAEC and EC_{25} levels. Given that spray droplet sizes are not specified on the saflufenacil label for aerial applications, an ASAE "fine to medium" spray is assumed. Label language specifies the boom length and release height for aerial applications at ¾ the length of the wingspan and 10 feet, respectively; therefore, these values were entered as inputs to the Tier III aerial AgDRIFT model. In addition, the default 'Maximum Downwind Distance' of 2,608 feet was increased to 1 mile (5280 feet) with the understanding that any calculations beyond 2,608 feet increases the uncertainty associated with the results. The results of the AgDRIFT modeling for ground applications of saflufenacil are provided in **Table E.5**.

Table E.5. Results of AgDRIFT Modeling for Aerial Applications of Saflufenacil

Use (Application Rate)	Dissipation Distance (ft)			
	Listed Plants		Non-listed Plants	
	Monocots	Dicots	Monocots	Dicots
Non-agricultural areas (0.354 lbs a.i./A)	> 5,280	> 5,280	2,926	> 5,280
Corn, sorghum, fallow, small grains (0.134 lbs a.i./A)	> 5,280	> 5,280	1,188	> 5,280
Soybeans and legumes (0.089 lbs a.i./A)	> 5,280	> 5,280	629	4,984
Cotton and sunflower (0.045 lbs a.i./A)	> 5,280	4,400	302	3,763

The results of the Tier III AgDRIFT modeling for aerial application of saflufenacil show that buffer distances greater than 1 mile would be required to dissipate spray drift to NOAEC levels for all modeled use patterns, with the exception of cotton and sunflower use. The spray drift distance that is protective of listed dicots based on aerial application of saflufenacil to cotton and sunflower at a rate of 0.045 lbs a.i./A is 4,400 feet. For non-listed monocots, the range of protective aerial spray drift buffers is 302 to 2,926 feet; for non-listed dicots, the range is 3,736 to >5,280 feet.

Appendix F. LOCATES Output of Listed Species.

Table F. Species Listing forNon-Agricultural Uses of Saflufenacil

Common Name	Scientific Name	Taxon
Frog, California Red-legged	Rana aurora draytonii	Amphibian
Salamander, Santa Cruz Long-toed	Ambystoma macrodactylum croceum	Amphibian
Salamander, Shenandoah	Plethodon shenandoah	Amphibian
Salamander, Sonora Tiger	Ambystoma tigrinum stebbinsi	Amphibian
Salamander, Texas Blind	Typhlomolge rathbuni	Amphibian
Frog, Dusky Gopher (Mississippi DPS)	Rana capito sevosa	Amphibian
Salamander, California Tiger	Ambystoma californiense	Amphibian
Salamander, San Marcos	Eurycea nana	Amphibian
Salamander, Red Hills	Phaeognathus hubrichti	Amphibian
Salamander, Desert Slender	Batrachoseps aridus	Amphibian
Frog, Chiricahua Leopard	Rana chiricahuensis	Amphibian
Salamander, Barton Springs	Eurycea sosorum	Amphibian
Toad, Arroyo Southwestern	Bufo californicus (=microscaphus)	Amphibian
Toad, Houston	Bufo houstonensis	Amphibian
Toad, Puerto Rican Crested	Peltophryne lemur	Amphibian
Salamander, Flatwoods	Ambystoma cingulatum	Amphibian
Toad, Wyoming	Bufo baxteri (=hemiophrys)	Amphibian
Guajon	Eleutherodactylus cooki	Amphibian
Frog, Mountain Yellow-legged	Gopherus agassizii	Amphibian
Coqui, Golden	Eleutherodactylus jasperi	Amphibian
Salamander, Cheat Mountain	Plethodon nettingi	Amphibian
Meshweaver, Braken Bat Cave	Cicurina venii	Arachnid
Spider, Kauai Cave Wolf	Gopherus polyphemus	Arachnid
Spider, Vesper Cave	Cicurina vespera	Arachnid
Spider, Spruce-fir Moss	Microhexura montivaga	Arachnid
Spider, Madla's Cave	Cicurina madla	Arachnid
Spider, Robber Baron Cave	Cicurina baronia	Arachnid
Harvestman, Robber Baron Cave	Texella cokendolpheri	Arachnid
Spider, Tooth Cave	Neoleptoneta myopica	Arachnid
Harvestman, Bone Cave	Texella reyesi	Arachnid
Harvestman, Bee Creek Cave	Texella reddelli	Arachnid
Spider, Government Canyon Cave	Neoleptoneta microps	Arachnid
Pseudoscorpion, Tooth Cave	Tartarocreagris texana	Arachnid
'Akepa, Hawaii	Loxops coccineus coccineus	Bird
'Akepa, Maui	Loxops coccineus ochraceus	Bird
'Akia Loa, Kauai (Hemignathus procerus)	Hemignathus procerus	Bird
Shearwater, Newell's Townsend's	Puffinus auricularis newelli	Bird
'Akia Pola'au (Hemignathus munroi)	Hemignathus munroi	Bird
Towhee, Inyo Brown	Pipilo crissalis eremophilus	Bird
Goose, Hawaiian (Nene)	Branta (=Nesochen) sandvicensis	Bird

Pelican, Brown	Pelecanus occidentalis	Bird
Parrotbill, Maui	Pseudonestor xanthophrys	Bird
Eagle, Bald	Haliaeetus leucocephalus	Bird
Plover, Piping	Charadrius melodus	Bird
Kite, Everglade Snail	Rostrhamus sociabilis plumbeus	Bird
Thrush, Small Kauai (Puaiohi)	Myadestes palmeri	Bird
Thrush, Molokai (Oloma'o)	Myadestes lanaiensis rutha	Bird
Thrush, Large Kauai	Myadestes myadestinus	Bird
Sparrow, San Clemente Sage	Amphispiza belli clementeae	Bird
Tern, Roseate	Sterna dougallii dougallii	Bird
Crane, Mississippi Sandhill	Grus canadensis pulla	Bird
Tern, Interior (population) Least	Sterna antillarum	Bird
Tern, California Least	Sterna antillarum browni	Bird
Swiftlet, Mariana Gray (=Vanikoro)	Aerodramus vanikorensis bartschi	Bird
'O'u (Honeycreeper)	Psittirostra psittacea	Bird
Parrot, Puerto Rican	Amazona vittata	Bird
White-eye, Ponape greater	Rukia longirostra	Bird
Cahow	Pterodroma cahow	Bird
Petrel, Hawaiian Dark-rumped	Pterodroma phaeopygia sandwichensis	Bird
Hawk, Hawaiian (Io)	Buteo solitarius	Bird
Hawk, Puerto Rican Broad-winged	Buteo platypterus brunnescens	Bird
Hawk, Puerto Rican Sharp-shinned	Accipiter striatus venator	Bird
Honeycreeper, Crested ('Akohekohe)	Palmeria dolei	Bird
Elepaio, Oahu	Chasiempis sandwichensis ibidis	Bird
Scrub-Jay, Florida	Aphelocoma coerulescens	Bird
Woodpecker, Red-cockaded	Picoides borealis	Bird
Vireo, Black-capped	Vireo atricapilla	Bird
Shrike, San Clemente Loggerhead	Lanius ludovicianus mearnsi	Bird
Vireo, Least Bell's	Vireo bellii pusillus	Bird
White-eye, Bridled (Nossa)	Zosterops conspicillatus conspicillatus	Bird
Kingfisher, Guam Micronesian	Halcyon cinnamomina cinnamomina	Bird
Warbler, Bachman's	Vermivora bachmanii	Bird
Pigeon, Puerto Rican Plain	Columba inornata wetmorei	Bird
Millerbird, Nihoa	Acrocephalus familiaris kingi	Bird
Warbler (=Wood), Kirtland's	Dendroica kirtlandii	Bird
Warbler (=Wood), Golden-cheeked	Dendroica chrysoparia	Bird
Warbler, nightingale reed (old world warbler)	Acrocephalus luscinia	Bird
Gnatcatcher, Coastal California	Polioptila californica californica	Bird
Woodpecker, Ivory-billed	Campephilus principalis	Bird
Creeper, Molokai (Kakawahie)	Paroreomyza flammea	Bird
Finch, Laysan	Telespyza cantans	Bird
Moorhen, Mariana Common	Gallinula chloropus guami	Bird
Crane, Whooping	Grus americana	Bird
Rail, Guam	Rallus owstoni	Bird
Eider, Spectacled	Somateria fischeri	Bird
Nightjar, Puerto Rico	Caprimulgus noctitherus	Bird
Caracara, Audubon's Crested	Polyborus plancus audubonii	Bird
Falcon, Northern Aplomado	Falco femoralis septentrionalis	Bird

White-eye, Rota Bridled	Zosterops rotensis	Bird
Coot, Hawaiian (=Alae keo keo)	Fulica americana alai	Bird
Creeper, Oahu (Alauwahio)	Paroreomyza maculata	Bird
Rail, California Clapper	Rallus longirostris obsoletus	Bird
Creeper, Hawaii	Oreomystis mana	Bird
Prairie-chicken, Attwater's Greater	Tympanuchus cupido attwateri	Bird
Rail, Light-footed Clapper	Rallus longirostris levipes	Bird
Duck, Laysan	Anas laysanensis	Bird
Bobwhite, Masked	Colinus virginianus ridgwayi	Bird
Duck, Hawaiian (Koloa)	Anas wyvilliana	Bird
Nuku Pu'u	Hemignathus lucidus	Bird
Murrelet, Marbled	Brachyramphus marmoratus marmoratus	Bird
Rail, Yuma Clapper	Rallus longirostris yumanensis	Bird
Albatross, Short-tailed	Phoebastria (=Diomedea) albatrus	Bird
Crow, Hawaiian ('Alala)	Corvus hawaiiensis	Bird
Palila	Loxioides bailleui	Bird
Eider, Steller's	Polysticta stelleri	Bird
Stork, Wood	Mycteria americana	Bird
Stilt, Hawaiian (=Ae'o)	Himantopus mexicanus knudseni	Bird
Starling, Ponape Mountain	Aplonis pelzelni	Bird
Condor, California	Gymnogyps californianus	Bird
Plover, Western Snowy	Charadrius alexandrinus nivosus	Bird
Megapode, Micronesian (La Perouse's)	Megapodius laperouse	Bird
'O'o, Kauai (='A'a)	Moho braccatus	Bird
Po'ouli	Melamprosops phaeosoma	Bird
Flycatcher, Southwestern Willow	Empidonax traillii extimus	Bird
Finch, Nihoa	Telespyza ultima	Bird
Curlew, Eskimo	Numenius borealis	Bird
Owl, Northern Spotted	Strix occidentalis caurina	Bird
Owl, Mexican Spotted	Strix occidentalis lucida	Bird
Crow, White-necked	Corvus leucognaphalus	Bird
Crow, Mariana	Corvus kubaryi	Bird
Sparrow, Florida Grasshopper	Ammodramus savannarum floridanus	Bird
Sparrow, Cape Sable Seaside	Ammodramus maritimus mirabilis	Bird
Blackbird, Yellow-shouldered	Agelaius xanthomus	Bird
Moorhen, Hawaiian Common	Gallinula chloropus sandvicensis	Bird
Pygmy-owl, Cactus Ferruginous	Glaucidium brasilianum cactorum	Bird
Coral, Elkhorn	Acropora palmata	Coral
Coral, Staghorn	Acropora cervicornis	Coral
Amphipod, Illinois Cave	Gammarus acherondytes	Crustacean
Isopod, Lee County Cave	Lirceus usdagalun	Crustacean
Isopod, Madison Cave	Antrolana lira	Crustacean
Isopod, Socorro	Thermosphaeroma thermophilus	Crustacean
Shrimp, Alabama Cave	Palaemonias alabamae	Crustacean
Shrimp, California Freshwater	Syncaris pacifica	Crustacean
Fairy Shrimp, Conservancy Fairy	Branchinecta conservatio	Crustacean
Fairy Shrimp, Longhorn	Branchinecta longiantenna	Crustacean
Fairy Shrimp, Riverside	Streptocephalus woottoni	Crustacean

Fairy Shrimp, San Diego	Branchinecta sandiegonensis	Crustacean
Fairy Shrimp, Vernal Pool	Branchinecta lynchi	Crustacean
Tadpole Shrimp, Vernal Pool	Lepidurus packardi	Crustacean
Shrimp, Squirrel Chimney Cave	Palaemonetes cummingi	Crustacean
Shrimp, Kentucky Cave	Palaemonias ganteri	Crustacean
Crayfish, Nashville	Orconectes shoupi	Crustacean
Amphipod, Hay's Spring	Stygobromus hayi	Crustacean
Amphipod, Kauai Cave	Spelaeorchestia koloana	Crustacean
Abalone, White	Haliotis sorenseni	Crustacean
Crayfish, Cave (Cambarus aculabrum)	Cambarus aculabrum	Crustacean
Amphipod, Peck's Cave	Stygobromus (=Stygonectes) pecki	Crustacean
Crayfish, Cave (Cambarus zophonastes)	Cambarus zophonastes	Crustacean
Crayfish, Shasta	Pacifastacus fortis	Crustacean
Amphipod, Noel's	Gammarus desperatus	Crustacean
Cactus, Pima Pineapple	Coryphantha scheeri var. robustispina	Dicot
Four-o'clock, Macfarlane's	Mirabilis macfarlanei	Dicot
Flannelbush, Pine Hill	Fremontodendron californicum ssp. decumbens	Dicot
Mitracarpus Polycladus	Mitracarpus polycladus	Dicot
Mitracarpus Maxwelliae	Mitracarpus maxwelliae	Dicot
Mint, Scrub	Dicerandra frutescens	Dicot
Mint, San Diego Mesa	Pogogyne abramsii	Dicot
Cactus, San Rafael	Pediocactus despainii	Dicot
Mint, Longspurred	Dicerandra cornutissima	Dicot
Monkey-flower, Michigan	Mimulus glabratus var. michiganensis	Dicot
Mint, Lakela's	Dicerandra immaculata	Dicot
Mint, Garrett's	Dicerandra christmanii	Dicot
Cactus, Mesa Verde	Sclerocactus mesae-verdae	Dicot
Cactus, Nellie Cory	Coryphantha minima	Dicot
Milkweed, Welsh's	Asclepias welshii	Dicot
Milkweed, Mead's	Asclepias meadii	Dicot
Milkpea, Small's	Galactia smallii	Dicot
Mint, Otay Mesa	Pogogyne nudiuscula	Dicot
Cactus, Kuenzler Hedgehog	Echinocereus fendleri var. kuenzleri	Dicot
Cactus, Siler Pincushion	Pediocactus (=Echinocactus,=Utahia) sileri	Dicot
Dudleya, Conejo	Dudleya abramsii ssp. parva	Dicot
Dudleya, Marcescent	Dudleya cymosa ssp. marcescens	Dicot
Dudleya, Santa Clara Valley	Dudleya setchellii	Dicot
Dudleya, Santa Monica Mountains	Dudleya cymosa ssp. ovatifolia	Dicot
Dudleya, Verity's	Dudleya verityi	Dicot
Monardella, Willowy	Monardella linoides ssp. viminea	Dicot
Cactus, Knowlton	Pediocactus knowltonii	Dicot
Cactus, Peebles Navajo	Pediocactus peeblesianus peeblesianus	Dicot
Cactus, Lee Pincushion	Coryphantha sneedii var. leei	Dicot
Mountainbalm, Indian Knob	Eriodictyon altissimum	Dicot
Cactus, Lloyd's Mariposa	Echinomastus mariposensis	Dicot
Morning-glory, Stebbins	Calystegia stebbinsii	Dicot
Fiddleneck, Large-flowered	Amsinckia grandiflora	Dicot
Flannelbush, Mexican	Fremontodendron mexicanum	Dicot

Monkshood, Northern Wild	Aconitum noveboracense	Dicot
Cordia bellonis (ncn)	Cordia bellonis	Dicot
Meadowfoam, Sebastopol	Limnanthes vinculans	Dicot
Milk-vetch, Clara Hunt's	Astragalus clarianus	Dicot
Milk-vetch, Braunton's	Astragalus brauntonii	Dicot
Milk-vetch, Ash Meadows	Astragalus phoenix	Dicot
Milk-vetch, Applegate's	Astragalus applegatei	Dicot
Mehamehame (Flueggea neowawraea)	Flueggea neowawraea	Dicot
Fringe Tree, Pygmy	Chionanthus pygmaeus	Dicot
Milk-vetch, Triple-ribbed	Astragalus tricarinatus	Dicot
Manzanita, Del Mar	Arctostaphylos glandulosa ssp. crassifolia	Dicot
Milk-vetch, Cushenbury	Astragalus albens	Dicot
Meadowfoam, Butte County	Limnanthes floccosa ssp. californica	Dicot
Cactus, Nichol's Turk's Head	Echinocactus horizonthalonius var. nicholii	Dicot
Mapele (Cyrtandra cyaneoides)	Cyrtandra cyaneoides	Dicot
Manzanita, Presidio (=Raven's)	Arctostaphylos hookeri var. ravenii	Dicot
Manzanita, Pallid	Arctostaphylos pallida	Dicot
Manzanita, Morro	Arctostaphylos morroensis	Dicot
Manzanita, Ione	Arctostaphylos myrtifolia	Dicot
Meadowrue, Cooley's	Thalictrum cooleyi	Dicot
Manioc, Walker's	Manihot walkerae	Dicot
Cobana Negra	Stahlia monosperma	Dicot
Coneflower, Tennessee Purple	Echinacea tennesseensis	Dicot
Mallow, Kern	Eremalche kernensis	Dicot
Mallow, Peter's Mountain	Iliamna corei	Dicot
Cactus, Cochise Pincushion	Coryphantha robbinsorum	Dicot
Milk-vetch, Sentry	Astragalus cremnophylax var. cremnophylax	Dicot
Coneflower, Smooth	Echinacea laevigata	Dicot
Milk-vetch, Coachella Valley	Astragalus lentiginosus var. coachellae	Dicot
Milk-vetch, Pierson's	Astragalus magdalenae var. peirsonii	Dicot
Milk-vetch, Coastal Dunes	Astragalus tener var. titi	Dicot
Milk-vetch, Osterhout	Astragalus osterhoutii	Dicot
Milk-vetch, Mancos	Astragalus humillimus	Dicot
Milk-vetch, Lane Mountain	Astragalus jaegerianus	Dicot
Milk-vetch, Jesup's	Astragalus robbinsii var. jesupi	Dicot
Milk-vetch, Heliotrope	Astragalus montii	Dicot
Milk-vetch, Fish Slough	Astragalus lentiginosus var. piscinensis	Dicot
Fleabane, Zuni	Erigeron rhizomatus	Dicot
Frankenia, Johnston's	Frankenia johnstonii	Dicot
Paintbrush, San Clemente Island Indian	Castilleja grisea	Dicot
Palo de Ramon	Banara vanderbiltii	Dicot
Haha (Cyanea superba)	Cyanea superba	Dicot
Palo de Nigua	Cornutia obovata	Dicot
Palo de Jazmin	Styrax portoricensis	Dicot
Palo Colorado (Ternstroemia luquillensis)	Ternstroemia luquillensis	Dicot
Butterweed, Layne's	Senecio layneae	Dicot
Button-celery, San Diego	Eryngium aristulatum var. parishii	Dicot
Paintbrush, Tiburon	Castilleja affinis ssp. neglecta	Dicot

Buttercup, Autumn	Ranunculus aestivalis (=acriformis)	Dicot
Paintbrush, Golden	Castilleja levisecta	Dicot
Paintbrush, Ash-grey Indian	Castilleja cinerea	Dicot
Oxytheca, Cushenbury	Oxytheca parishii var. goodmaniana	Dicot
Crownscale, San Jacinto Valley	Atriplex coronata var. notatior	Dicot
Crownbeard, Big-leaved	Verbesina dissita	Dicot
Clover, Fleshy Owl's	Castilleja campestris ssp. succulenta	Dicot
Dubautia pauciflorula (ncn)	Dubautia pauciflorula	Dicot
Haha (Cyanea St-Johnii) (=Rollandia St-Johnii)	Cyanea st-johnii	Dicot
Daisy, Parish's	Erigeron parishii	Dicot
Phacelia, Clay	Phacelia argillacea	Dicot
Daisy, Lakeside	Hymenoxys herbacea	Dicot
Peperomia, Wheeler's	Peperomia wheeleri	Dicot
Pentachaeta, White-rayed	Pentachaeta bellidiflora	Dicot
Pentachaeta, Lyon's	Pentachaeta lyonii	Dicot
Penstemon, Blowout	Penstemon haydenii	Dicot
Pennyroyal, Todsen's	Hedeoma todsenii	Dicot
Palo de Rosa	Ottoschulzia rhodoxylon	Dicot
Clover, Prairie Bush	Lespedeza leptostachya	Dicot
Cycladenia, Jones	Cycladenia jonesii (=humilis)	Dicot
Pawpaw, Rugel's	Deeringothamnus rugelii	Dicot
Pawpaw, Four-petal	Asimina tetramera	Dicot
Pawpaw, Beautiful	Deeringothamnus pulchellus	Dicot
Taraxacum, California	Taraxacum californicum	Dicot
Daphnopsis hellerana (ncn)	Daphnopsis hellerana	Dicot
Bush-mallow, San Clemente Island	Malacothamnus clementinus	Dicot
Cactus, Arizona Hedgehog	Echinocereus triglochidiatus var. arizonicus	Dicot
Daisy, Maguire	Erigeron maguirei	Dicot
Mustard, Carter's	Warea carteri	Dicot
Navarretia, Few-flowered	Navarretia leucocephala ssp. pauciflora (=N. pauciflora)	Dicot
Cactus, Black Lace	Echinocereus reichenbachii var. albertii	Dicot
Nanu (Gardenia mannii)	Gardenia mannii	Dicot
Nani Wai'ale'ale (Viola kauaensis var. wahiawaensis)	Viola kauaiensis var. wahiawaensis	Dicot
Na'u (Gardenia brighamii)	Gardenia brighamii	Dicot
Myrcia Paganii	Myrcia paganii	Dicot
Butterwort, Godfrey's	Pinguicula ionantha	Dicot
Mustard, Penland Alpine Fen	Eutrema penlandii	Dicot
Nehe (Lipochaeta fauriei)	Lipochaeta fauriei	Dicot
Dubautia latifolia (ncn)	Dubautia latifolia	Dicot
Munroidendron racemosum (ncn)	Munroidendron racemosum	Dicot
Cactus, Brady Pincushion	Pediocactus bradyi	Dicot
Cactus, Bunched Cory	Coryphantha ramillosa	Dicot
Cactus, Chisos Mountain Hedgehog	Echinocereus chisoensis var. chisoensis	Dicot
Ma'oli'oli (Schiedea apokremnos)	Schiedea apokremnos	Dicot
Cactus, Key Tree	Pilosocereus robinii	Dicot
Mustard, Slender-petaled	Thelypodium stenopetalum	Dicot

Delissea rhytodisperma (ncn)	Delissea rhytidosperma	Dicot
Cactus, Bakersfield	Opuntia treleasei	Dicot
Oak, Hinckley	Quercus hinckleyi	Dicot
Nohoanu (Geranium multiflorum)	Geranium multiflorum	Dicot
Niterwort, Amargosa	Nitrophila mohavensis	Dicot
Nioi (Eugenia koolauensis)	Eugenia koolauensis	Dicot
Dawn-flower, Texas Prairie (=Texas Bitterweed)	Hymenoxys texana	Dicot
Neraudia angulata (ncn)	Neraudia angulata	Dicot
Navarretia, Many-flowered	Navarretia leucocephala ssp. plieantha	Dicot
Nehe (Lipochaeta tenuifolia)	Lipochaeta tenuifolia	Dicot
Navarretia, Spreading	Navarretia fossalis	Dicot
Nehe (Lipochaeta micrantha)	Lipochaeta micrantha	Dicot
Dogweed, Ashy	Thymophylla tephroleuca	Dicot
Coyote-thistle, Loch Lomond	Eryngium constancei	Dicot
Dropwort, Canby's	Oxypolis canbyi	Dicot
Nehe (Lipochaeta lobata var. leptophylla)	Lipochaeta lobata var. leptophylla	Dicot
Nehe (Lipochaeta kamolensis)	Lipochaeta kamolensis	Dicot
Checker-mallow, Nelson's	Sidalcea nelsoniana	Dicot
Nehe (Lipochaeta waimeaensis)	Lipochaeta waimeaensis	Dicot
Joint-vetch, Sensitive	Aeschynomene virginica	Dicot
Cactus, Sneed Pincushion	Coryphantha sneedii var. sneedii	Dicot
Kauila (Colubrina oppositifolia)	Colubrina oppositifolia	Dicot
Ha'Iwale (Cyrtandra limahuliensis)	Cyrtandra limahuliensis	Dicot
Ha'Iwale (Cyrtandra munroi)	Cyrtandra munroi	Dicot
Ha'Iwale (Cyrtandra polyantha)	Cyrtandra polyantha	Dicot
Kamakahala (Labordia tinifolia var. wahiawaen)	Labordia tinifolia var. wahiawaensis	Dicot
Kamakahala (Labordia lydgatei)	Labordia lydgatei	Dicot
Ha'Iwale (Cyrtandra giffardii)	Cyrtandra giffardii	Dicot
Ha'Iwale (Cyrtandra subumbellata)	Cyrtandra subumbellata	Dicot
Ha'Iwale (Cyrtandra dentata)	Cyrtandra dentata	Dicot
Jewelflower, Tiburon	Streptanthus niger	Dicot
Jewelflower, Metcalf Canyon	Streptanthus albidus ssp. albidus	Dicot
Ha'Iwale (Cyrtandra tintinnabula)	Cyrtandra tintinnabula	Dicot
Jewelflower, California	Caulanthus californicus	Dicot
Ha'Iwale (Cyrtandra viridiflora)	Cyrtandra viridiflora	Dicot
Haha (Cyanea acuminata)	Cyanea acuminata	Dicot
Haha (Cyanea asarifolia)	Cyanea asarifolia	Dicot
Kamakahala (Labordia cyrtandrae)	Labordia cyrtandrae	Dicot
Ko'oko'olau (Bidens micrantha ssp. kalealaha)	Bidens micrantha ssp. kalealaha	Dicot
Koki'o (Kokia drynarioides)	Kokia drynarioides	Dicot
Ko'oloa'ula (Abutilon menziesii)	Abutilon menziesii	Dicot
Ko'oko'olau (Bidens wiebkei)	Bidens wiebkei	Dicot
Clarkia, Presidio	Clarkia franciscana	Dicot
Clarkia, Pismo	Clarkia speciosa ssp. immaculata	Dicot
Potentilla, Hickman's	Potentilla hickmanii	Dicot
Grass, Hairy Orcutt	Orcuttia pilosa	Dicot

Kaulu (Pteralyxia kauaiensis)	Pteralyxia kauaiensis	Dicot
Grass, Slender Orcutt	Orcuttia tenuis	Dicot
Haha (Cyanea copelandii ssp. copelandii)	Cyanea copelandii ssp. copelandii	Dicot
Chupacallos	Pleodendron macranthum	Dicot
Kiponapona (Phyllostegia racemosa)	Phyllostegia racemosa	Dicot
Kio'Ele (Hedyotis coriacea)	Hedyotis coriacea	Dicot
Chumbo, Higo	Harrisia portoricensis	Dicot
Ground-plum, Guthrie's	Astragalus bibullatus	Dicot
Groundsel, San Francisco Peaks	Senecio franciscanus	Dicot
Gumplant, Ash Meadows	Grindelia fraxino-pratensis	Dicot
Grass, Sacramento Orcutt	Orcuttia viscida	Dicot
Haha (Cyanea platyphylla)	Cyanea platyphylla	Dicot
Heau (Exocarpos luteolus)	Exocarpos luteolus	Dicot
Heather, Mountain Golden	Hudsonia montana	Dicot
Heartleaf, Dwarf-flowered	Hexastylis naniflora	Dicot
Hayun Lagu (Tronkon Guafi)	Serianthes nelsonii	Dicot
Haha (Cyanea longiflora)	Cyanea longiflora	Dicot
Haha (Cyanea mannii)	Cyanea mannii	Dicot
Haha (Cyanea mceldowneyi)	Cyanea mceldowneyi	Dicot
Jacquemontia, Beach	Jacquemontia reclinata	Dicot
Haha (Cyanea pinnatifida)	Cyanea pinnatifida	Dicot
Hedyotis parvula (ncn)	Hedyotis parvula	Dicot
Harperella	Ptilimnium nodosum	Dicot
Harebells, Avon Park	Crotalaria avonensis	Dicot
Haplostachys Haplostachya (ncn)	Haplostachys haplostachya	Dicot
Haha (Cyanea stictophylla)	Cyanea stictophylla	Dicot
Haha (Cyanea shipmanii)	Cyanea shipmannii	Dicot
Haha (Cyanea procera)	Cyanea procera	Dicot
Haha (Cyanea recta)	Cyanea recta	Dicot
Hau Kauhiwi (Hibiscadelphus woodi)	Hibiscadelphus woodii	Dicot
Haha (Cyanea hamatiflora ssp. carlsonii)	Cyanea hamatiflora carlsonii	Dicot
Koki'o Ke'oke'o (Hibiscus waimeae ssp. hannerae)	Hibiscus waimeae ssp. hannerae	Dicot
Haha (Cyanea dunbarii)	Cyanea dunbarii	Dicot
Haha (Cyanea grimesiana ssp. grimesiana)	Cyanea grimesiana ssp. grimesiana	Dicot
Haha (Cyanea grimesiana ssp. obatae)	Cyanea grimesiana ssp. obatae	Dicot
Ipomopsis, Holy Ghost	Ipomopsis sancti-spiritus	Dicot
Iliau (Wilkesia hobdyi)	Wilkesia hobdyi	Dicot
Ilex sintenisii (ncn)	Ilex sintenisii	Dicot
Hedyotis degeneri (ncn)	Hedyotis degeneri	Dicot
Howellia, Water	Howellia aquatilis	Dicot
Haha (Cyanea koolauensis)	Cyanea koolauensis	Dicot
Holly, Cook's	Ilex cookii	Dicot
Higuero De Sierra	Crescentia portoricensis	Dicot
Hibiscus, Clay's	Hibiscus clayi	Dicot
Hesperomannia lydgatei (ncn)	Hesperomannia lydgatei	Dicot
Hesperomannia arbuscula (ncn)	Hesperomannia arbuscula	Dicot
Hesperomannia arborescens (ncn)	Hesperomannia arborescens	Dicot

Hedyotis St.-Johnii (ncn)	Hedyotis st.-johnii	Dicot
Ivesia, Ash Meadows	Ivesia kingii var. eremica	Dicot
Hypericum, Highlands Scrub	Hypericum cumulicola	Dicot
Locoweed, Fassett's	Oxytropis campestris var. chartacea	Dicot
Capa Rosa	Callicarpa ampla	Dicot
Gerardia, Sandplain	Agalinis acuta	Dicot
Loosestrife, Rough-leaved	Lysimachia asperulaefolia	Dicot
Gesneria pauciflora (ncn)	Gesneria pauciflora	Dicot
Gilia, Monterey	Gilia tenuiflora ssp. arenaria	Dicot
Clarkia, Vine Hill	Clarkia imbricata	Dicot
Lomatium, Bradshaw's	Lomatium bradshawii	Dicot
Ceanothus, Pine Hill	Ceanothus roderickii	Dicot
Chamaecrista glandulosa (ncn)	Chamaecrista glandulosa var. mirabilis	Dicot
Cactus, Wright Fishhook	Sclerocactus wrightiae	Dicot
Lobelia oahuensis (ncn)	Lobelia oahuensis	Dicot
Lobelia niihauensis (ncn)	Lobelia niihauensis	Dicot
Lobelia monostachya (ncn)	Lobelia monostachya	Dicot
Cat's-eye, Terlingua Creek	Cryptantha crassipes	Dicot
Liveforever, Santa Barbara Island	Dudleya traskiae	Dicot
Liveforever, Laguna Beach	Dudleya stolonifera	Dicot
Koki'o (Kokia kauaiensis)	Kokia kauaiensis	Dicot
Goetzea, Beautiful (Matabuey)	Goetzea elegans	Dicot
Fruit, Earth (=geocarpon)	Geocarpon minimum	Dicot
Haha (Cyanea remyi)	Cyanea remyi	Dicot
Ma'o Hau Hele (Hibiscus brackenridgei)	Hibiscus brackenridgei	Dicot
Lysimachia maxima (ncn)	Lysimachia maxima	Dicot
Lysimachia lydgatei (ncn)	Lysimachia lydgatei	Dicot
Clover, Showy Indian	Trifolium amoenum	Dicot
Lysimachia filifolia (ncn)	Lysimachia filifolia	Dicot
Clover, Running Buffalo	Trifolium stoloniferum	Dicot
Campion, Fringed	Silene polypetala	Dicot
Cliffrose, Arizona	Purshia (=cowania) subintegra	Dicot
Calyptranthes Thomasiana (ncn)	Calyptranthes thomasiana	Dicot
Lyonia truncata var. proctorii (ncn)	Lyonia truncata var. proctorii	Dicot
Geranium, Hawaiian Red-flowered	Geranium arboreum	Dicot
Lupine, Scrub	Lupinus aridorum	Dicot
Lupine, Clover	Lupinus tidestromii	Dicot
Lousewort, Furbish	Pedicularis furbishiae	Dicot
Cactus, Tobusch Fishhook	Ancistrocactus tobuschii	Dicot
Cactus, Uinta Basin Hookless	Sclerocactus glaucus	Dicot
Golden Sunburst, Hartweg's	Pseudobahia bahiifolia	Dicot
Clover, Monterey	Trifolium trichocalyx	Dicot
Clarkia, Springville	Clarkia springvillensis	Dicot
Laukahi Kuahiwi (Plantago princeps)	Plantago princeps	Dicot
Laukahi Kuahiwi (Plantago hawaiensis)	Plantago hawaiensis	Dicot
Chamaesyce Halemanui (ncn)	Chamaesyce halemanui	Dicot
Larkspur, Yellow	Delphinium luteum	Dicot
Larkspur, San Clemente Island	Delphinium variegatum ssp. kinkiense	Dicot

Larkspur, Baker's	Delphinium bakeri	Dicot
Checker-mallow, Kenwood Marsh	Sidalcea oregana ssp. valida	Dicot
Ceanothus, Coyote	Ceanothus ferrisae	Dicot
Phacelia, North Park	Phacelia formosula	Dicot
Gouania vitifolia (ncn)	Gouania vitifolia	Dicot
Primrose, Maguire	Primula maguirei	Dicot
Checker-mallow, Pedate	Sidalcea pedata	Dicot
Kulu'I (Nototrichium humile)	Nototrichium humile	Dicot
Kuawawaenohu (Alsinidendron lychnoides)	Alsinidendron lychnoides	Dicot
Kolea (Myrsine linearifolia)	Myrsine linearifolia	Dicot
Kolea (Myrsine juddii)	Myrsine juddii	Dicot
Cactus, Star	Astrophytum asterias	Dicot
Gourd, Okeechobee	Cucurbita okeechobeensis ssp. okeechobeensis	Dicot
Gooseberry, Miccosukee	Ribes echinellum	Dicot
Goldenrod, Blue Ridge	Solidago spithamaea	Dicot
Goldenrod, Houghton's	Solidago houghtonii	Dicot
Goldenrod, Short's	Solidago shortii	Dicot
Goldenrod, White-haired	Solidago albopilosa	Dicot
Goldfields, Burke's	Lasthenia burkei	Dicot
Goldfields, Contra Costa	Lasthenia conjugens	Dicot
Ceanothus, Vail Lake	Ceanothus ophiochilus	Dicot
Laulihilihi (Schiedea stellarioides)	Schiedea stellarioides	Dicot
Lessingia, San Francisco	Lessingia germanorum (=L.g. var. germanorum)	Dicot
Layia, Beach	Layia carnosa	Dicot
Leptocereus grantianus (ncn)	Leptocereus grantianus	Dicot
Chaffseed, American	Schwalbea americana	Dicot
Leather-flower, Morefield's	Clematis morefieldii	Dicot
Leather-flower, Alabama	Clematis socialis	Dicot
Lead-plant, Crenulate	Amorpha crenulata	Dicot
Gouania hillebrandii (ncn)	Gouania hillebrandii	Dicot
Gouania meyenii (ncn)	Gouania meyenii	Dicot
Koki'o Ke'oke'o (Hibiscus arnottianus ssp. immaculatus)	Hibiscus arnottianus ssp. immaculatus	Dicot
Centaury, Spring-loving	Centaurium namophilum	Dicot
Haha (Cyanea hamatiflora ssp. hamatiflora)	Cyanea hamatiflora ssp. hamatiflora	Dicot
Schiedea spergulina var. leiopoda (ncn)	Schiedea spergulina var. leiopoda	Dicot
Schiedea haleakalensis (ncn)	Schiedea haleakalensis	Dicot
Popolo Ku Mai (Solanum incompletum)	Solanum incompletum	Dicot
Haha (Cyanea Macrostegia var. gibsonii)	Cyanea macrostegia ssp. gibsonii	Dicot
Haha (Cyanea humboldtiana)	Cyanea humboldtiana	Dicot
Kamakahala (Labordia triflora)	Labordia triflora	Dicot
Kamakahala (Labordia tinifolia var. lanaiensis)	Labordia tinifolia var. lanaiensis	Dicot
Kanaloa kahoolawensis (ncn)	Kanaloa kahoolawensis	Dicot
Pamakani (Viola chamissoniana ssp. chamissoniana)	Viola chamissoniana ssp. chamissoniana	Dicot
Na'ena'e (Dubautia plantaginea ssp. humilis)	Dubautia plantaginea ssp. humilis	Dicot
Ma'oli'oli (Schiedea kealiae)	Schiedea kealiae	Dicot
Haha (Cyanea glabra)	Cyanea glabra	Dicot

Haha (Cyanea copelandii ssp. haleakalaensis)	Cyanea copelandii ssp. haleakalaensis	Dicot
'Oha Wai (Clermontia samuelii)	Clermontia samuelii	Dicot
Alani (Melicope munroi)	Melicope munroi	Dicot
Rock-cress, Santa Cruz Island	Sibara filifolia	Dicot
Woodland-star, San Clemente Island	Lithophragma maximum	Dicot
Mountain-mahogany, Catalina Island	Cercocarpus traskiae	Dicot
Checker-mallow, Keck's	Sidalcea keckii	Dicot
Kopa (Hedyotis schlechtendahliana var. remyi)	Hedyotis schlechtendahliana var. remyi	Dicot
Hau Kuahiwi (Hibiscadelphus hualalaiensis)	Hibiscadelphus hualalaiensis	Dicot
Silene hawaiiensis (ncn)	Silene hawaiiensis	Dicot
Naupaka, Dwarf (Scaevola coriacea)	Scaevola coriacea	Dicot
Makou (Peucedanum sandwicense)	Peucedanum sandwicense	Dicot
Neraudia ovata (ncn)	Neraudia ovata	Dicot
Neraudia sericea (ncn)	Neraudia sericea	Dicot
Lipochaeta venosa (ncn)	Lipochaeta venosa	Dicot
Liliwai (Acaena exigua)	Acaena exigua	Dicot
Koki'o, Cooke's (Kokia cookei)	Kokia cookei	Dicot
Tetramolopium arenarium (ncn)	Tetramolopium arenarium	Dicot
Hau Kuahiwi (Hibiscadelphus distans)	Hibiscadelphus distans	Dicot
Trematolobelia singularis (ncn)	Trematolobelia singularis	Dicot
Hau Kuahiwi (Hibiscadelphus giffardianus)	Hibiscadelphus giffardianus	Dicot
Cyanea undulata (ncn)	Cyanea undulata	Dicot
Haha (Cyanea truncata)	Cyanea truncata	Dicot
Haha (Cyanea lobata)	Cyanea lobata	Dicot
Ha'Iwale (Cyrtandra crenata)	Cyrtandra crenata	Dicot
Aupaka (Isodendrion longifolium)	Isodendrion longifolium	Dicot
Aupaka (Isodendrion laurifolium)	Isodendrion laurifolium	Dicot
Silversword, Mauna Kea ('Ahinahina)	Argyroxiphium sandwicense ssp. sandwicense	Dicot
Dudleya, Santa Cruz Island	Dudleya nesiotica	Dicot
Holei (Ochrosia kilaueaensis)	Ochrosia kilaueaensis	Dicot
Vigna o-wahuensis (ncn)	Vigna o-wahuensis	Dicot
Checker-mallow, Wenatchee Mountains	Sidalcea oregana var. calva	Dicot
Water-willow, Cooley's	Justicia cooleyi	Dicot
Warea, Wide-leaf	Warea amplexifolia	Dicot
Walnut, Nogal	Juglans jamaicensis	Dicot
Wallflower, Menzie's	Erysimum menziesii	Dicot
Wallflower, Contra Costa	Erysimum capitatum var. angustatum	Dicot
Wallflower, Ben Lomond	Erysimum teretifolium	Dicot
Prickly-apple, Fragrant	Cereus eriophorus var. fragrans	Dicot
Whitlow-wort, Papery	Paronychia chartacea	Dicot
Phlox, Texas Trailing	Phlox nivalis ssp. texensis	Dicot
Wild-buckwheat, Clay-loving	Eriogonum pelinophilum	Dicot
Vetch, Hawaiian (Vicia menziesii)	Vicia menziesii	Dicot
Vervain, California	Verbena californica	Dicot
Vernonia Proctorii (ncn)	Vernonia proctorii	Dicot
Uvillo	Eugenia haematocarpa	Dicot
Umbel, Huachuca Water	Lilaeopsis schaffneriana var. recurva	Dicot

Ulihi (Phyllostegia glabra var. lanaiensis)	Phyllostegia glabra var. lanaiensis	Dicot
Uhiuhi (Caesalpinia kavaiensis)	Caesalpinia kavaiense	Dicot
Twinpod, Dudley Bluffs	Physaria obcordata	Dicot
Silene alexandri (ncn)	Silene alexandri	Dicot
Viola lanaiensis (ncn)	Viola lanaiensis	Dicot
Manzanita, Santa Rosa Island	Arctostaphylos confertiflora	Dicot
Phyllostegia knudsenii (ncn)	Phyllostegia knudsenii	Dicot
Fringepod, Santa Cruz Island	Thysanocarpus conchuliferus	Dicot
Phacelia, Island	Phacelia insularis ssp. insularis	Dicot
Malacothrix, Island	Malacothrix squalida	Dicot
Malacothrix, Santa Cruz Island	Malacothrix indecora	Dicot
Bush-mallow, Santa Cruz Island	Malacothamnus fasciculatus var. nesioticus	Dicot
Gilia, Hoffmann's Slender-flowered	Gilia tenuiflora ssp. hoffmannii	Dicot
Bedstraw, Island	Galium buxifolium	Dicot
Watercress, Gambel's	Rorippa gambellii	Dicot
Barberry, Island	Berberis pinnata ssp. insularis	Dicot
Rush-rose, Island	Helianthemum greenei	Dicot
Rock-cress, Hoffmann's	Arabis hoffmannii	Dicot
Ziziphus, Florida	Ziziphus celata	Dicot
Xylosma crenatum (ncn)	Xylosma crenatum	Dicot
Woolly-threads, San Joaquin	Monolopia (=Lembertia) congdonii	Dicot
Woolly-star, Santa Ana River	Eriastrum densifolium ssp. sanctorum	Dicot
Wireweed	Polygonella basiramia	Dicot
Wire-lettuce, Malheur	Stephanomeria malheurensis	Dicot
Wings, Pigeon	Clitoria fragrans	Dicot
Wild-buckwheat, Gypsum	Eriogonum gypsophilum	Dicot
Paintbrush, Soft-leaved	Castilleja mollis	Dicot
Aster, Florida Golden	Chrysopsis floridana	Dicot
Amaranth, Seabeach	Amaranthus pumilus	Dicot
Osmoxylon mariannense (ncn)	Osmoxylon mariannense	Dicot
Nesogenes rotensis (ncn)	Nesogenes rotensis	Dicot
Na'ena'e (Dubautia herbstobatae)	Gopherus polyphemus	Dicot
Catchfly, Spalding's	Silene spaldingii	Dicot
Ambrosia, San Diego	Ambrosia pumila	Dicot
Amaranthus brownii (ncn)	Amaranthus brownii	Dicot
Ambrosia, South Texas	Ambrosia cheiranthifolia	Dicot
Opuhe (Urera kaalae)	Urera kaalae	Dicot
Aster, Decurrent False	Boltonia decurrens	Dicot
Stickseed, Showy	Hackelia venusta	Dicot
Aster, Ruth's Golden	Pityopsis ruthii	Dicot
Auerodendron pauciflorum (ncn)	Auerodendron pauciflorum	Dicot
Milk-vetch, Ventura Marsh	Astragalus pycnostachyus var. lanosissimus	Dicot
Aupaka (Isodendrion hosakae)	Isodendrion hosakae	Dicot
Avens, Spreading	Geum radiatum	Dicot
Ayenia, Texas	Ayenia limitaris	Dicot
Baccharis, Encinitas	Baccharis vanessae	Dicot
Barbara Buttons, Mohr's	Marshallia mohrii	Dicot
Amphianthus, Little	Amphianthus pusillus	Dicot

Alani (Melicope saint-johnii)	Melicope saint-johnii	Dicot
Alani (Melicope adscendens)	Melicope adscendens	Dicot
Alani (Melicope balloui)	Melicope balloui	Dicot
Alani (Melicope haupuensis)	Melicope haupuensis	Dicot
Alani (Melicope knudsenii)	Melicope knudsenii	Dicot
Alani (Melicope lydgatei)	Melicope lydgatei	Dicot
Alani (Melicope mucronulata)	Melicope mucronulata	Dicot
Alani (Melicope ovalis)	Melicope ovalis	Dicot
Alani (Melicope pallida)	Melicope pallida	Dicot
Lomatium, Cook's	Lomatium cookii	Dicot
Alani (Melicope reflexa)	Melicope reflexa	Dicot
Meadowfoam, Large-flowered Woolly	Limnanthes floccosa ssp. Grandiflora	Dicot
Alani (Melicope zahlbruckneri)	Melicope zahlbruckneri	Dicot
Allocarya, Calistoga	Plagiobothrys strictus	Dicot
Polygonum, Scott's Valley	Polygonum hickmanii	Dicot
Alsinidendron obovatum (ncn)	Alsinidendron obovatum	Dicot
Alsinidendron trinerve (ncn)	Alsinidendron trinerve	Dicot
Alsinidendron viscosum (ncn)	Alsinidendron viscosum	Dicot
Milk-vetch, Holmgren	Astragalus holmgreniorum	Dicot
Milk-vetch, Shivwits	Astragalus ampullarioides	Dicot
Bear-poppy, Dwarf	Arctomecon humilis	Dicot
Alani (Melicope quadrangularis)	Melicope quadrangularis	Dicot
Sea-blite, California	Suaeda californica	Dicot
Barberry, Nevin's	Berberis nevinii	Dicot
Tarplant, Santa Cruz	Holocarpha macradenia	Dicot
Thelypody, Howell's Spectacular	Thelypodium howellii spectabilis	Dicot
Sunflower, Pecos	Helianthus paradoxus	Dicot
Schiedea verticillata (ncn)	Schiedea verticillata	Dicot
Sneezeweed, Virginia	Helenium virginicum	Dicot
Schoepfia arenaria (ncn)	Schoepfia arenaria	Dicot
Bird's-beak, Soft	Cordylanthus mollis ssp. mollis	Dicot
Thistle, La Graciosa	Cirsium loncholepis	Dicot
Popcornflower, Rough	Plagiobothrys hirtus	Dicot
Yerba Santa, Lompoc	Eriodictyon capitatum	Dicot
Catesbaea Melanocarpa (ncn)	Catesbaea melanocarpa	Dicot
Wahine Noho Kula (Isodendrion pyrifolium)	Isodendrion pyrifolium	Dicot
Schiedea, Diamond Head (Schiedea adamantis)	Schiedea adamantis	Dicot
Schiedea nuttallii (ncn)	Schiedea nuttallii	Dicot
Schiedea kauaiensis (ncn)	Schiedea kauaiensis	Dicot
Schiedea hookeri (ncn)	Schiedea hookeri	Dicot
Sanicula purpurea (ncn)	Sanicula purpurea	Dicot
Haha (Cyanea Crispa) (=Rollandia crispa)	Cyanea (=Rollandia) crispa	Dicot
Phyllostegia parviflora (ncn)	Phyllostegia parviflora	Dicot
Thistle, Suisun	Cirsium hydrophilum var. hydrophilum	Dicot
Milk-vetch, Deseret	Astragalus desereticus	Dicot
Viola helenae (ncn)	Viola helenae	Dicot
Cactus, Winkler	Pediocactus winkleri	Dicot

Phlox, Yreka	Phlox hirsuta	Dicot
Beardtongue, Penland	Penstemon penlandii	Dicot
Bedstraw, El Dorado	Galium californicum ssp. sierrae	Dicot
Bellflower, Brooksville	Campanula robinsiae	Dicot
Schiedea helleri (ncn)	Schiedea helleri	Dicot
Schiedea kaalae (ncn)	Schiedea kaalae	Dicot
Schiedea spergulina var. spergulina (ncn)	Schiedea spergulina var. spergulina	Dicot
Penny-cress, Kneeland Prairie	Thlaspi californicum	Dicot
Bariaco	Trichilia triacantha	Dicot
Bladderpod, Zapata	Lesquerella thamnophila	Dicot
Schiedea lydgatei (ncn)	Schiedea lydgatei	Dicot
Lupine, Kincaid's	Lupinus sulphureus (=oreganus) ssp. kincaidii (=var. kincaidii)	Dicot
Daisy, Willamette	Erigeron decumbens var. decumbens	Dicot
Schiedea membranacea (ncn)	Schiedea membranacea	Dicot
Butterfly Plant, Colorado	Gaura neomexicana var. coloradensis	Dicot
Schiedea sarmentosa (ncn)	Schiedea sarmentosa	Dicot
Lupine, Nipomo Mesa	Lupinus nipomensis	Dicot
Tarplant, Gaviota	Deinandra increscens ssp. villosa	Dicot
Yellowhead, Desert	Yermo xanthocephalus	Dicot
Rock-cress, Shale Barren	Arabis serotina	Dicot
Reed-mustard, Barneby	Schoenocrambe barnebyi	Dicot
Sand-verbena, Large-fruited	Abronia macrocarpa	Dicot
Bladderpod, Kodachrome	Lesquerella tumulosa	Dicot
Bladderpod, Lyrate	Lesquerella lyrata	Dicot
Rush-pea, Slender	Hoffmannseggia tenella	Dicot
Roseroot, Leedy's	Sedum integrifolium ssp. leedyi	Dicot
Rosemary, Short-leaved	Conradina brevifolia	Dicot
Rosemary, Etonia	Conradina etonia	Dicot
Rosemary, Cumberland	Conradina verticillata	Dicot
Sandlace	Polygonella myriophylla	Dicot
Rock-cress, Small	Arabis perstellata E. L. Braun var. perstellata Fernald	Dicot
Sandwort, Bear Valley	Arenaria ursina	Dicot
Rock-cress, McDonald's	Arabis mcdonaldiana	Dicot
Rock-cress, Large (=Braun's)	Arabis perstellata E. L. Braun var. ampla Rollins	Dicot
Ridge-cress (=Pepper-cress), Barneby	Lepidium barnebyanum	Dicot
Bladderpod, Missouri	Lesquerella filiformis	Dicot
Rhododendron, Chapman	Rhododendron chapmanii	Dicot
Remya, Maui	Remya mauiensis	Dicot
Remya montgomeryi (ncn)	Remya montgomeryi	Dicot
Remya kauaiensis (ncn)	Remya kauaiensis	Dicot
Reed-mustard, Shrubby	Schoenocrambe suffrutescens	Dicot
A'e (Zanthoxylum hawaiiense)	Zanthoxylum hawaiiense	Dicot
Rosemary, Apalachicola	Conradina glabra	Dicot
Bird's-beak, Pennell's	Cordylanthus tenuis ssp. capillaris	Dicot
Abutilon eremitopetalum (ncn)	Abutilon eremitopetalum	Dicot
Silene lanceolata (ncn)	Silene lanceolata	Dicot
Snowbells, Texas	Styrax texanus	Dicot

Viola oahuensis (ncn)	Viola oahuensis	Dicot
Snakeroot	Eryngium cuneifolium	Dicot
Abutilon sandwicense (ncn)	Abutilon sandwicense	Dicot
Achyranthes mutica (ncn)	Achyranthes mutica	Dicot
Achyranthes splendens var. rotundata (ncn)	Achyranthes splendens var. rotundata	Dicot
Adobe Sunburst, San Joaquin	Pseudobahia peirsonii	Dicot
Sandalwood, Lanai (='Iliahi)	Santalum freycinetianum var. lanaiense	Dicot
Bird's-beak, Palmate-bracted	Cordylanthus palmatus	Dicot
Rattleweed, Hairy	Baptisia arachnifera	Dicot
Bird's-beak, salt marsh	Cordylanthus maritimus ssp. maritimus	Dicot
Skullcap, Large-flowered	Scutellaria montana	Dicot
Skullcap, Florida	Scutellaria floridana	Dicot
Birds-in-a-nest, White	Macbridea alba	Dicot
Bittercress, Small-anthered	Cardamine micranthera	Dicot
Bladderpod, Dudley Bluffs	Lesquerella congesta	Dicot
Silversword, Ka'u (Argyroxiphium kauense)	Argyroxiphium kauense	Dicot
Sanicula mariversa (ncn)	Sanicula mariversa	Dicot
Sandwort, Marsh	Arenaria paludicola	Dicot
Sandwort, Cumberland	Arenaria cumberlandensis	Dicot
Birch, Virginia Round-leaf	Betula uber	Dicot
Pinkroot, Gentian	Spigelia gentianoides	Dicot
Reed-mustard, Clay	Schoenocrambe argillacea	Dicot
Buckwheat, Cushenbury	Eriogonum ovalifolium var. vineum	Dicot
Buckwheat, Ione (incl. Irish Hill)	Eriogonum apricum (incl. var. prostratum)	Dicot
Po'e (Portulaca sclerocarpa)	Portulaca sclerocarpa	Dicot
Plum, Scrub	Prunus geniculata	Dicot
Buckwheat, Scrub	Eriogonum longifolium var. gnaphalifolium	Dicot
Pitcher-plant, Mountain Sweet	Sarracenia rubra ssp. jonesii	Dicot
Pitcher-plant, Green	Sarracenia oreophila	Dicot
Pitcher-plant, Alabama Canebrake	Sarracenia rubra alabamensis	Dicot
Polygala, Tiny	Polygala smallii	Dicot
Buckwheat, Southern Mountain Wild	Eriogonum kennedyi var. austromontanum	Dicot
Pondberry	Lindera melissifolia	Dicot
Buckwheat, Steamboat	Eriogonum ovalifolium var. williamsiae	Dicot
Pilo (Hedyotis mannii)	Hedyotis mannii	Dicot
Phyllostegia wawrana (ncn)	Phyllostegia wawrana	Dicot
Phyllostegia warshaueri (ncn)	Phyllostegia warshaueri	Dicot
Phyllostegia waimeae (ncn)	Phyllostegia waimeae	Dicot
Phyllostegia velutina (ncn)	Phyllostegia velutina	Dicot
Phyllostegia mollis (ncn)	Phyllostegia mollis	Dicot
Phyllostegia mannii (ncn)	Phyllostegia mannii	Dicot
Phyllostegia kaalaensis (ncn)	Phyllostegia kaalaensis	Dicot
Phyllostegia hirsuta (ncn)	Phyllostegia hirsuta	Dicot
Pitaya, Davis' Green	Echinocereus viridiflorus var. davisii	Dicot
Bonamia menziesii (ncn)	Bonamia menziesii	Dicot
Bladderpod, San Bernardino Mountains	Lesquerella kingii ssp. bernardina	Dicot
Bladderpod, Spring Creek	Lesquerella perforata	Dicot
Pussypaws, Mariposa	Calyptridium pulchellum	Dicot

Bladderpod, White	Lesquerella pallida	Dicot
Blazing Star, Ash Meadows	Mentzelia leucophylla	Dicot
Blazing Star, Heller's	Liatris helleri	Dicot
Blazing Star, Scrub	Liatris ohlingerae	Dicot
Blue-star, Kearney's	Amsonia kearneyana	Dicot
Bluecurls, Hidden Lake	Trichostema austromontanum ssp. compactum	Dicot
Polygala, Lewton's	Polygala lewtonii	Dicot
Pua'ala (Brighamia rockii)	Brighamia rockii	Dicot
Spermolepis hawaiiensis (ncn)	Spermolepis hawaiiensis	Dicot
Mahoe (Alectryon macrococcus)	Alectryon macrococcus	Dicot
Prickly-ash, St. Thomas	Zanthoxylum thomasianum	Dicot
Clover, Leafy Prairie	Dalea foliosa	Dicot
Bonamia, Florida	Bonamia grandiflora	Dicot
Potato-bean, Price's	Apios priceana	Dicot
Poppy-mallow, Texas	Callirhoe scabriuscula	Dicot
Poppy, Sacramento Prickly	Argemone pleiacantha ssp. pinnatisecta	Dicot
Popolo 'Aiakeakua (Solanum sandwicense)	Solanum sandwicense	Dicot
Boxwood, Vahl's	Buxus vahlii	Dicot
Broom, San Clemente Island	Lotus dendroideus ssp. traskiae	Dicot
Bluet, Roan Mountain	Hedyotis purpurea var. montana	Dicot
A'e (Zanthoxylum dipetalum var. tomentosum)	Zanthoxylum dipetalum var. tomentosum	Dicot
Erubia	Solanum drymophilum	Dicot
Tetramolopium lepidotum ssp. lepidotum (ncn)	Tetramolopium lepidotum ssp. lepidotum	Dicot
Tetramolopium filiforme (ncn)	Tetramolopium filiforme	Dicot
Tetramolopium capillare (ncn)	Tetramolopium capillare	Dicot
Ternstroemia subsessilis (ncn)	Ternstroemia subsessilis	Dicot
Tarplant, Otay	Deinandra (=Hemizonia) conjugens	Dicot
Sunray, Ash Meadows	Enceliopsis nudicaulis var. corrugata	Dicot
Tetramolopium rockii (ncn)	Tetramolopium rockii	Dicot
Sunflower, San Mateo Woolly	Eriophyllum latilobum	Dicot
Thistle, Chorro creek Bog	Cirsium fontinale var. obispoense	Dicot
'Anaunau (Lepidium arbuscula)	Lepidium arbuscula	Dicot
'Anunu (Sicyos alba)	Sicyos alba	Dicot
'Awikiwiki (Canavalia molokaiensis)	Canavalia molokaiensis	Dicot
'Awiwi (Centaurium sebaeoides)	Centaurium sebaeoides	Dicot
'Awiwi (Hedyotis cookiana)	Hedyotis cookiana	Dicot
Dwarf-flax, Marin	Hesperolinon congestum	Dicot
Stonecrop, Lake County	Parvisedum leiocarpum	Dicot
Stickyseed, Baker's	Blennosperma bakeri	Dicot
Sunflower, Schweinitz's	Helianthus schweinitzii	Dicot
Townsendia, Last Chance	Townsendia aprica	Dicot
Silene perlmanii (ncn)	Silene perlmanii	Dicot
Silversword, Haleakala ('Ahinahina)	Argyroxiphium sandwicense ssp. macrocephalum	Dicot
'Aiea (Nothocestrum breviflorum)	Nothocestrum breviflorum	Dicot
'Aiea (Nothocestrum peltatum)	Nothocestrum peltatum	Dicot
Tuctoria, Green's	Tuctoria greenei	Dicot

'Akoko (Chamaesyce celastroides var. kaenana)	Chamaesyce celastroides var. kaenana	Dicot
'Akoko (Chamaesyce deppeana)	Chamaesyce deppeana	Dicot
Tetramolopium remyi (ncn)	Tetramolopium remyi	Dicot
'Akoko (Chamaesyce kuwaleana)	Chamaesyce kuwaleana	Dicot
Sumac, Michaux's	Rhus michauxii	Dicot
'Akoko (Chamaesyce rockii)	Chamaesyce rockii	Dicot
'Akoko (Chamaesyce skottsbergii var. skottsbe	Chamaesyce skottsbergii var. kalaeloana	Dicot
'Akoko (Euphorbia haeleeleana)	Euphorbia haeleeleana	Dicot
Thornmint, San Mateo	Acanthomintha obovata ssp. duttonii	Dicot
Thornmint, San Diego	Acanthomintha ilicifolia	Dicot
Thistle, Sacramento Mountains	Cirsium vinaceum	Dicot
Thistle, Pitcher's	Cirsium pitcheri	Dicot
Thistle, Fountain	Cirsium fontinale var. fontinale	Dicot
'Akoko (Chamaesyce herbstii)	Chamaesyce herbstii	Dicot
Spineflower, Sonoma	Chorizanthe valida	Dicot
'Oha Wai (Clermontia oblongifolia ssp. mauiensis)	Clermontia oblongifolia ssp. mauiensis	Dicot
Stenogyne kanehoana (ncn)	Stenogyne kanehoana	Dicot
Spurge, Telephus	Euphorbia telephioides	Dicot
Spurge, Hoover's	Chamaesyce hooveri	Dicot
Spurge, Garber's	Chamaesyce garberi	Dicot
Spurge, Deltoid	Chamaesyce deltoidea ssp. deltoidea	Dicot
'Oha Wai (Clermontia pyrularia)	Clermontia pyrularia	Dicot
'Ohai (Sesbania tomentosa)	Sesbania tomentosa	Dicot
'Oha Wai (Clermontia oblongifolia ssp. brevipes)	Clermontia oblongifolia ssp. brevipes	Dicot
Spiraea, Virginia	Spiraea virginiana	Dicot
'Oha Wai (Clermontia peleana)	Clermontia peleana	Dicot
Spineflower, Slender-horned	Dodecahema leptoceras	Dicot
Spineflower, Scotts Valley	Chorizanthe robusta var. hartwegii	Dicot
Spineflower, Robust	Chorizanthe robusta var. robusta	Dicot
Spineflower, Orcutt's	Chorizanthe orcuttiana	Dicot
Spineflower, Monterey	Chorizanthe pungens var. pungens	Dicot
Spineflower, Howell's	Chorizanthe howellii	Dicot
Spineflower, Ben Lomond	Chorizanthe pungens var. hartwegiana	Dicot
'Olulu (Brighamia insignis)	Brighamia insignis	Dicot
'Ohe'ohe (Tetraplasandra gymnocarpa)	Tetraplasandra gymnocarpa	Dicot
'Oha (Lobelia gaudichaudii koolauensis)	Lobelia gaudichaudii ssp. koolauensis	Dicot
'Oha Wai (Clermontia lindseyana)	Clermontia lindseyana	Dicot
'Oha (Delissea subcordata)	Delissea subcordata	Dicot
'Oha (Delissea rivularis)	Delissea rivularis	Dicot
Evening-primrose, San Benito	Camissonia benitensis	Dicot
Evening-primrose, Eureka Valley	Oenothera avita ssp. eurekensis	Dicot
Evening-primrose, Antioch Dunes	Oenothera deltoides ssp. howellii	Dicot
'Oha (Delissea undulata)	Delissea undulata	Dicot
Eugenia Woodburyana	Eugenia woodburyana	Dicot
Stenogyne angustifolia (ncn)	Stenogyne angustifolia var. angustifolia	Dicot

'Oha Wai (Clermontia drepanomorpha)	Clermontia drepanomorpha	Dicot
Stenogyne bifida (ncn)	Stenogyne bifida	Dicot
Stenogyne campanulata (ncn)	Stenogyne campanulata	Dicot
Shiner, Beautiful	Cyprinella formosa	Fish
Shiner, Cahaba	Notropis cahabae	Fish
Shiner, Blue	Cyprinella caerulea	Fish
Cui-ui	Chasmistes cujus	Fish
Silverside, Waccamaw	Menidia extensa	Fish
Chub, Yaqui	Gila purpurea	Fish
Dace, Ash Meadows Speckled	Rhinichthys osculus nevadensis	Fish
Dace, Blackside	Phoxinus cumberlandensis	Fish
Dace, Clover Valley Speckled	Rhinichthys osculus oligoporus	Fish
Chub, Spotfin	Erimonax monachus	Fish
Chub, Hutton Tui	Gila bicolor ssp.	Fish
Chub, Owens Tui	Gila bicolor snyderi	Fish
Chub, Oregon	Oregonichthys crameri	Fish
Shiner, Palezone	Notropis albizonatus	Fish
Shiner, Pecos Bluntnose	Notropis simus pecosensis	Fish
Chub, Virgin River	Gila seminuda (=robusta)	Fish
Dace, Desert	Eremichthys acros	Fish
Shiner, Arkansas River	Notropis girardi	Fish
Shiner, Cape Fear	Notropis mekistocholas	Fish
Chub, Slender	Erimystax cahni	Fish
Chub, Sonora	Gila ditaenia	Fish
Chub, Mohave Tui	Gila bicolor mohavensis	Fish
Chub, Humpback	Gila cypha	Fish
Chub, Chihuahua	Gila nigrescens	Fish
Chub, Borax Lake	Gila boraxobius	Fish
Chub, Bonytail	Gila elegans	Fish
Catfish, Yaqui	Ictalurus pricei	Fish
Cavefish, Alabama	Speoplatyrhinus poulsoni	Fish
Cavefish, Ozark	Amblyopsis rosae	Fish
Chub, Pahranagat Roundtail	Gila robusta jordani	Fish
Sculpin, Pygmy	Cottus paulus (=pygmaeus)	Fish
Springfish, Railroad Valley	Crenichthys nevadae	Fish
Dace, Foskett Speckled	Rhinichthys osculus ssp.	Fish
Chub, Gila	Gila intermedia	Fish
Madtom, Smoky	Noturus baileyi	Fish
Spikedace	Meda fulgida	Fish
Spinedace, Big Spring	Lepidomeda mollispinis pratensis	Fish
Spinedace, Little Colorado	Lepidomeda vittata	Fish
Logperch, Roanoke	Percina rex	Fish
Springfish, Hiko White River	Crenichthys baileyi grandis	Fish
Salmon, Coho	Oncorhynchus (=Salmo) kisutch	Fish
Springfish, White River	Crenichthys baileyi baileyi	Fish
Squawfish, Colorado	Ptychocheilus lucius	Fish
Steelhead, (California Central Valley population)	Oncorhynchus (=Salmo) mykiss	Fish

Steelhead, (Central California Coast population)	Oncorhynchus (=Salmo) mykiss	Fish
Steelhead, (Lower Columbia River population)	Oncorhynchus (=Salmo) mykiss	Fish
Steelhead, (Northern California population)	Oncorhynchus (=Salmo) mykiss	Fish
Spinedace, White River	Lepidomeda albivallis	Fish
Pupfish, Ash Meadows Amargosa	Cyprinodon nevadensis mionectes	Fish
Madtom, Neosho	Noturus placidus	Fish
Madtom, Pygmy	Noturus stanauli	Fish
Madtom, Scioto	Noturus trautmani	Fish
Madtom, Yellowfin	Noturus flavipinnis	Fish
Minnow, Loach	Tiaroga cobitis	Fish
Minnow, Rio Grande Silvery	Hybognathus amarus	Fish
Smelt, Delta	Hypomesus transpacificus	Fish
Steelhead, Puget Sound	Oncorhynchus mykiss	Fish
Salmon, Sockeye	Oncorhynchus (=Salmo) nerka	Fish
Pupfish, Desert	Cyprinodon macularius	Fish
Pupfish, Devils Hole	Cyprinodon diabolis	Fish
Pupfish, Leon Springs	Cyprinodon bovinus	Fish
Pupfish, Owens	Cyprinodon radiosus	Fish
Pupfish, Warm Springs	Cyprinodon nevadensis pectoralis	Fish
Sturgeon, North American green	Acipenser medirostris	Fish
Steelhead, (Southern California population)	Oncorhynchus (=Salmo) mykiss	Fish
Poolfish, Pahrump (= Pahrump Killifish)	Empetrichthys latos	Fish
Sucker, Santa Ana	Catostomus santaanae	Fish
Steelhead, (Snake River Basin population)	Oncorhynchus (=Salmo) mykiss	Fish
Trout, Paiute Cutthroat	Oncorhynchus clarki seleniris	Fish
Sawfish, Smalltooth	Pristis pectinata	Fish
Darter, Vermilion	Etheostoma chermocki	Fish
Woundfin	Plagopterus argentissimus	Fish
Salmon, Atlantic	Salmo salar	Fish
Trout, Lahontan Cutthroat	Oncorhynchus clarki henshawi	Fish
Sturgeon, Alabama	Scaphirhynchus suttkusi	Fish
Trout, Greenback Cutthroat	Oncorhynchus clarki stomias	Fish
Steelhead, (Middle Columbia River population)	Oncorhynchus (=Salmo) mykiss	Fish
Steelhead, (Upper Willamette River population)	Oncorhynchus (=Salmo) mykiss	Fish
Salmon, Chum	Oncorhynchus (=Salmo) keta	Fish
Salmon, Sockeye (Ozette Lake population)	Oncorhynchus (=Salmo) nerka	Fish
Salmon, Chinook	Oncorhynchus (=Salmo) tshawytscha	Fish
Minnow, Devils River	Dionda diaboli	Fish
Trout, Bull	Salvelinus confluentus	Fish
Shiner, Topeka	Notropis topeka (=tristis)	Fish
Sucker, Lost River	Deltistes luxatus	Fish
Pupfish, Comanche Springs	Cyprinodon elegans	Fish
Steelhead, (Upper Columbia River population)	Oncorhynchus (=Salmo) mykiss	Fish
Stickleback, Unarmored Threespine	Gasterosteus aculeatus williamsoni	Fish

Sturgeon, Gulf	Acipenser oxyrinchus desotoi	Fish
Sturgeon, Pallid	Scaphirhynchus albus	Fish
Sturgeon, Shortnose	Acipenser brevirostrum	Fish
Trout, Little Kern Golden	Oncorhynchus aguabonita whitei	Fish
Sucker, June	Chasmistes liorus	Fish
Steelhead, (South-Central California population)	Oncorhynchus (=Salmo) mykiss	Fish
Sucker, Modoc	Catostomus microps	Fish
Sucker, Razorback	Xyrauchen texanus	Fish
Sucker, Shortnose	Chasmistes brevirostris	Fish
Sucker, Warner	Catostomus warnerensis	Fish
Topminnow, Gila (Yaqui)	Poeciliopsis occidentalis	Fish
Trout, Apache	Oncorhynchus apache	Fish
Trout, Gila	Oncorhynchus gilae	Fish
Sturgeon, White	Acipenser transmontanus	Fish
Darter, Bluemask (=jewel)	Etheostoma /	Fish
Darter, Duskytail	Etheostoma percnurum	Fish
Darter, Cherokee	Etheostoma scotti	Fish
Darter, Watercress	Etheostoma nuchale	Fish
Gambusia, Big Bend	Gambusia gaigei	Fish
Darter, Snail	Percina tanasi	Fish
Darter, Slackwater	Etheostoma boschungi	Fish
Darter, Relict	Etheostoma chienense	Fish
Goby, Tidewater	Eucyclogobius newberryi	Fish
Darter, Okaloosa	Etheostoma okaloosae	Fish
Darter, Niangua	Etheostoma nianguae	Fish
Darter, Etowah	Etheostoma etowahae	Fish
Darter, Maryland	Etheostoma sellare	Fish
Darter, Boulder	Etheostoma wapiti	Fish
Darter, Amber	Percina antesella	Fish
Darter, Leopard	Percina pantherina	Fish
Darter, Goldline	Percina aurolineata	Fish
Dace, Independence Valley Speckled	Rhinichthys osculus lethoporus	Fish
Darter, Fountain	Etheostoma fonticola	Fish
Dace, Kendall Warm Springs	Rhinichthys osculus thermalis	Fish
Logperch, Conasauga	Percina jenkinsi	Fish
Dace, Moapa	Moapa coriacea	Fish
Gambusia, San Marcos	Gambusia georgei	Fish
Gambusia, Pecos	Gambusia nobilis	Fish
Darter, Bayou	Etheostoma rubrum	Fish
Gambusia, Clear Creek	Gambusia heterochir	Fish
Beetle, Comal Springs Riffle	Heterelmis comalensis	Insect
Rhadine infernalis (ncn)	Rhadine infernalis	Insect
Rhadine exilis (ncn)	Rhadine exilis	Insect
Beetle, Valley Elderberry Longhorn	Desmocerus californicus dimorphus	Insect
Fly, Hawaiian picture-wing	Drosophila musaphilia	Insect
Beetle, Delta Green Ground	Elaphrus viridis	Insect
Fly, Delhi Sands Flower-loving	Rhaphiomidas terminatus abdominalis	Insect

Beetle, Salt Creek Tiger	Cicindela nevadica lincolniana	Insect
Skipper, Laguna Mountain	Pyrgus ruralis lagunae	Insect
Skipper, Pawnee Montane	Hesperia leonardus montana	Insect
Dragonfly, Hine's Emerald	Somatochlora hineana	Insect
Beetle, Northeastern Beach Tiger	Cicindela dorsalis dorsalis	Insect
Beetle, Helotes Mold	Batrisodes venyivi	Insect
Beetle, Hungerford's Crawling Water	Brychius hungerfordi	Insect
Fly, Hawaiian picture-wing	Drosophila neoclavisetae	Insect
Beetle, Comal Springs Dryopid	Stygoparnus comalensis	Insect
Butterfly, Mitchell's Satyr	Neonympha mitchellii mitchellii	Insect
Beetle, American Burying	Nicrophorus americanus	Insect
Butterfly, Bay Checkerspot (Wright's euphydryas)	Euphydryas editha bayensis	Insect
Beetle, Puritan Tiger	Cicindela puritana	Insect
Fly, Hawaiian picture-wing	Drosophila ochrobasis	Insect
Beetle, Mount Hermon June	Polyphylla barbata	Insect
Moth, Blackburn's Sphinx	Manduca blackburni	Insect
Butterfly, Lotis Blue	Lycaeides argyrognomon lotis	Insect
Butterfly, Fender's Blue	Icaricia icarioides fenderi	Insect
Naucorid, Ash Meadows	Ambrysus amargosus	Insect
Beetle, Tooth Cave Ground	Rhadine persephone	Insect
Beetle, Kretschmarr Cave Mold	Texamaurops reddelli	Insect
Fly, Hawaiian picture-wing	Drosophila tarphytrichia	Insect
Fly, Hawaiian picture-wing	Drosophila substenoptera	Insect
Beetle, Coffin Cave Mold	Batrisodes texanus	Insect
Butterfly, Uncompahgre Fritillary	Boloria acrocnema	Insect
Moth, Kern Primrose Sphinx	Euproserpinus euterpe	Insect
Fly, Hawaiian picture-wing	Drosophila differens	Insect
Fly, Hawaiian picture-wing	Drosophila mulli	Insect
Fly, Hawaiian picture-wing	Drosophila obatai	Insect
Fly, Hawaiian picture-wing	Drosophila hemipeza	Insect
Fly, Hawaiian picture-wing	Drosophila montgomeryi	Insect
Fly, Hawaiian picture-wing	Drosophila aglaia	Insect
Grasshopper, Zayante Band-winged	Trimerotropis infantilis	Insect
Butterfly, Oregon Silverspot	Speyeria zerene hippolyta	Insect
Butterfly, Callippe Silverspot	Speyeria callippe callippe	Insect
Butterfly, El Segundo Blue	Euphilotes battoides allyni	Insect
Butterfly, Karner Blue	Lycaeides melissa samuelis	Insect
Butterfly, Lange's Metalmark	Apodemia mormo langei	Insect
Fly, Hawaiian picture-wing	Drosophila heteroneura	Insect
Butterfly, Mission Blue	Icaricia icarioides missionensis	Insect
Beetle, Ohlone Tiger	Cicindela ohlone	Insect
Butterfly, Myrtle's Silverspot	Speyeria zerene myrtleae	Insect
Butterfly, Behren's Silverspot	Speyeria zerene behrensii	Insect
Butterfly, Palos Verdes Blue	Glaucopsyche lygdamus palosverdesensis	Insect
Butterfly, Quino Checkerspot	Euphydryas editha quino (=E. e. wrighti)	Insect
Butterfly, Saint Francis' Satyr	Neonympha mitchellii francisci	Insect
Butterfly, San Bruno Elfin	Callophrys mossii bayensis	Insect

Butterfly, Schaus Swallowtail	Heraclides aristodemus ponceanus	Insect
Butterfly, Smith's Blue	Euphilotes enoptes smithi	Insect
Skipper, Carson Wandering	Pseudocopaeodes eunus obscurus	Insect
Squirrel, Virginia Northern Flying	Glaucomys sabrinus fuscus	Mammal
Woodrat, Riparian	Neotoma fuscipes riparia	Mammal
Squirrel, Mount Graham Red	Tamiasciurus hudsonicus grahamensis	Mammal
Woodrat, Key Largo	Neotoma floridana smalli	Mammal
Wolf, Red	Canis rufus	Mammal
Wolf, Gray	Canis lupus	Mammal
Vole, Hualapai Mexican	Microtus mexicanus hualpaiensis	Mammal
Vole, Florida Salt Marsh	Microtus pennsylvanicus dukecampbelli	Mammal
Vole, Amargosa	Microtus californicus scirpensis	Mammal
Caribou, Woodland	Rangifer tarandus caribou	Mammal
Shrew, Buena Vista Lake Ornate	Sorex ornatus relictus	Mammal
Rabbit, Pygmy	Brachylagus idahoensis	Mammal
Sheep, Peninsular Bighorn	Ovis canadensis	Mammal
Fox, San Joaquin Kit	Vulpes macrotis mutica	Mammal
Fox, San Miguel Island	Urocyon littoralis littoralis	Mammal
Rabbit, Riparian Brush	Sylvilagus bachmani riparius	Mammal
Fox, Santa Rosa Island	Urocyon littoralis santarosae	Mammal
Fox, Santa Cruz Island	Urocyon littoralis santacruzae	Mammal
Deer, Columbian White-tailed	Odocoileus virginianus leucurus	Mammal
Deer, Key	Odocoileus virginianus clavium	Mammal
Puma (=Cougar), Eastern	Puma (=Felis) concolor couguar	Mammal
Dugong	Dugong dugon	Mammal
Ferret, Black-footed	Mustela nigripes	Mammal
Rabbit, Lower Keys Marsh	Sylvilagus palustris hefneri	Mammal
Bat, Gray	Myotis grisescens	Mammal
Squirrel, Delmarva Peninsula Fox	Sciurus niger cinereus	Mammal
Bear, Louisiana Black	Ursus americanus luteolus	Mammal
Rice Rat (=Silver Rice Rat)	Oryzomys palustris natator	Mammal
Bat, Virginia Big-eared	Corynorhinus (=Plecotus) townsendii virginianus	Mammal
Bat, Ozark Big-eared	Corynorhinus (=Plecotus) townsendii ingens	Mammal
Bat, Mexican Long-nosed	Leptonycteris nivalis	Mammal
Bat, Mariana Fruit (=Mariana Flying Fox)	Pteropus mariannus mariannus	Mammal
Bat, Little Mariana Fruit	Pteropus tokudae	Mammal
Bat, Lesser (=Sanborn's) Long-nosed	Leptonycteris curasoae yerbabuenae	Mammal
Panther, Florida	Puma (=Felis) concolor coryi	Mammal
Lynx, Canada	Lynx canadensis	Mammal
Bat, Hawaiian Hoary	Lasiurus cinereus semotus	Mammal
Sheep, Sierra Nevada Bighorn	Ovis canadensis californiana	Mammal
Ocelot	Leopardus (=Felis) pardalis	Mammal
Mouse, Southeastern Beach	Peromyscus polionotus niveiventris	Mammal
Mouse, Salt Marsh Harvest	Reithrodontomys raviventris	Mammal
Mouse, Perdido Key Beach	Peromyscus polionotus trissyllepsis	Mammal
Mouse, Pacific Pocket	Perognathus longimembris pacificus	Mammal
Mouse, Key Largo Cotton	Peromyscus gossypinus allapaticola	Mammal
Mouse, Choctawhatchee Beach	Peromyscus polionotus allophrys	Mammal

Mouse, Anastasia Island Beach	Peromyscus polionotus phasma	Mammal
Mouse, Alabama Beach	Peromyscus polionotus ammobates	Mammal
Kangaroo Rat, San Bernardino Merriam's	Dipodomys merriami parvus	Mammal
Bat, Indiana	Myotis sodalis	Mammal
Jaguarundi, Gulf Coast	Herpailurus (=Felis) yagouaroundi cacomitli	Mammal
Squirrel, Carolina Northern Flying	Glaucomys sabrinus coloratus	Mammal
Mouse, St. Andrew Beach	Peromyscus polionotus peninsularis	Mammal
Mouse, Preble's Meadow Jumping	Zapus hudsonius preblei	Mammal
Squirrel, Northern Idaho Ground	Spermophilus brunneus brunneus	Mammal
Fox, Santa Catalina Island	Urocyon littoralis catalinae	Mammal
Bear, Grizzly	Ursus arctos horribilis	Mammal
Jaguar	Panthera onca	Mammal
Kangaroo Rat, Fresno	Dipodomys nitratoides exilis	Mammal
Kangaroo Rat, Giant	Dipodomys ingens	Mammal
Kangaroo Rat, Morro Bay	Dipodomys heermanni morroensis	Mammal
Kangaroo Rat, Stephens'	Dipodomys stephensi (incl. D. cascus)	Mammal
Kangaroo Rat, Tipton	Dipodomys nitratoides nitratoides	Mammal
Mountain Beaver, Point Arena	Aplodontia rufa nigra	Mammal
Prairie Dog, Utah	Cynomys parvidens	Mammal
Pronghorn, Sonoran	Antilocapra americana sonoriensis	Mammal
Jaguarundi, Sinaloan	Herpailurus (=Felis) yagouaroundi tolteca	Mammal
Beargrass, Britton's	Nolina brittoniana	Monocot
Arrowhead, Bunched	Sagittaria fasciculata	Monocot
Sedge, Golden	Carex lutea	Monocot
Seagrass, Johnson's	Halophila johnsonii	Monocot
Amole, Purple	Chlorogalum purpureum var. purpureum	Monocot
Lo`ulu (Pritchardia schattaueri)	Pritchardia schattaueri	Monocot
Fritillary, Gentner's	Fritillaria gentneri	Monocot
Grass, Eureka Dune	Swallenia alexandrae	Monocot
Beaked-rush, Knieskern's	Rhynchospora knieskernii	Monocot
Sedge, Navajo	Carex specuicola	Monocot
Beauty, Harper's	Harperocallis flava	Monocot
Sedge, White	Carex albida	Monocot
Mariscus pennatiformis (ncn)	Mariscus pennatiformis	Monocot
Orchid, Western Prairie Fringed	Platanthera praeclara	Monocot
Grass, California Orcutt	Orcuttia californica	Monocot
Lily, Minnesota Trout	Erythronium propullans	Monocot
Brodiaea, Chinese Camp	Brodiaea pallida	Monocot
Brodiaea, Thread-leaved	Brodiaea filifolia	Monocot
Pondweed, Little Aguja Creek	Potamogeton clystocarpus	Monocot
Pogonia, Small Whorled	Isotria medeoloides	Monocot
Poa siphonoglossa (ncn)	Poa siphonoglossa	Monocot
Platanthera holochila (ncn)	Platanthera holochila	Monocot
Piperia, Yadon's	Piperia yadonii	Monocot
Pink, Swamp	Helonias bullata	Monocot
Bulrush, Northeastern (=Barbed Bristle)	Scirpus ancistrochaetus	Monocot
Pelos del Diablo	Aristida portoricensis	Monocot
Lepanthes eltorensis (ncn)	Lepanthes eltoroensis	Monocot

Manaca, palma de	Calyptronoma rivalis	Monocot
Lau'ehu (Panicum niihauense)	Panicum niihauense	Monocot
Orchid, Eastern Prairie Fringed	Platanthera leucophaea	Monocot
Onion, Munz's	Allium munzii	Monocot
Lily, Pitkin Marsh	Lilium pardalinum ssp. pitkinense	Monocot
Lily, Tiburon Mariposa	Calochortus tiburonensis	Monocot
Mariscus fauriei (ncn)	Mariscus fauriei	Monocot
Lily, Western	Lilium occidentale	Monocot
Lo`ulu (Pritchardia viscosa)	Pritchardia viscosa	Monocot
Lo`ulu (Pritchardia remota)	Pritchardia remota	Monocot
Lo`ulu (Pritchardia napaliensis)	Pritchardia napaliensis	Monocot
Lo`ulu (Pritchardia munroi)	Pritchardia munroi	Monocot
Lo`ulu (Pritchardia kaalae)	Pritchardia kaalae	Monocot
Lo`ulu (Pritchardia affinis)	Pritchardia affinis	Monocot
Panicgrass, Carter's (Panicum fauriei var.carteri)	Panicum fauriei var. carteri	Monocot
Iris, Dwarf Lake	Iris lacustris	Monocot
Water-plantain, Kral's	Sagittaria secundifolia	Monocot
Wahane (Pritchardia aylmer-robinsonii)	Pritchardia aylmer-robinsonii	Monocot
Alopecurus, Sonoma	Alopecurus aequalis var. sonomensis	Monocot
Trillium, Relict	Trillium reliquum	Monocot
Trillium, Persistent	Trillium persistens	Monocot
Cranichis Ricartii	Cranichis ricartii	Monocot
Gahnia Lanaiensis (ncn)	Gahnia lanaiensis	Monocot
Bluegrass, Hawaiian	Poa sandvicensis	Monocot
Grass, Colusa	Neostapfia colusana	Monocot
Grass, Fosberg's Love	Eragrostis fosbergii	Monocot
Grass, Solano	Tuctoria mucronata	Monocot
Grass, Tennessee Yellow-eyed	Xyris tennesseensis	Monocot
Pu'uka'a (Cyperus trachysanthos)	Cyperus trachysanthos	Monocot
Hilo Ischaemum (Ischaemum byrone)	Ischaemum byrone	Monocot
Wild-rice, Texas	Zizania texana	Monocot
Grass, San Joaquin Valley Orcutt	Orcuttia inaequalis	Monocot
Irisette, White	Sisyrinchium dichotomum	Monocot
Amole, Cammatta Canyon	Chlorogalum purpureum var. reductum	Monocot
Kamanomano (Cenchrus agrimonioides)	Cenchrus agrimonioides	Monocot
Ladies'-tresses, Canelo Hills	Spiranthes delitescens	Monocot
Ladies'-tresses, Navasota	Spiranthes parksii	Monocot
Aristida chaseae (ncn)	Aristida chaseae	Monocot
Ladies'-tresses, Ute	Spiranthes diluvialis	Monocot
Bluegrass, Mann's (Poa mannii)	Poa mannii	Monocot
Bluegrass, Napa	Poa napensis	Monocot
Bluegrass, San Bernardino	Poa atropurpurea	Monocot
Hala Pepe (Pleomele hawaiiensis)	Pleomele hawaiiensis	Monocot
Snake, Concho Water	Nerodia paucimaculata	Reptile
Lizard, St. Croix Ground	Ameiva polops	Reptile
Snake, Eastern Indigo	Drymarchon corais couperi	Reptile
Snake, Atlantic Salt Marsh	Nerodia clarkii taeniata	Reptile

Skink, Sand	Neoseps reynoldsi	Reptile
Skink, Blue-tailed Mole	Eumeces egregius lividus	Reptile
Rattlesnake, New Mexican Ridge-nosed	Crotalus willardi obscurus	Reptile
Boa, Mona	Epicrates monensis monensis	Reptile
Snake, Giant Garter	Thamnophis gigas	Reptile
Boa, Virgin Islands Tree	Epicrates monensis granti	Reptile
Snake, San Francisco Garter	Thamnophis sirtalis tetrataenia	Reptile
Lizard, Island Night	Xantusia riversiana	Reptile
Lizard, Coachella Valley Fringe-toed	Uma inornata	Reptile
Lizard, Blunt-nosed Leopard	Gambelia silus	Reptile
Iguana, Mona Ground	Cyclura stejnegeri	Reptile
Gecko, Monito	Sphaerodactylus micropithecus	Reptile
Crocodile, American	Crocodylus acutus	Reptile
Boa, Puerto Rican	Epicrates inornatus	Reptile
Sea turtle, Kemp's ridley	Lepidochelys kempii	Reptile
Turtle, Bog (Northern population)	Clemmys muhlenbergii	Reptile
Whipsnake (=Striped Racer), Alameda	Masticophis lateralis euryxanthus	Reptile
Turtle, Yellow-blotched Map	Graptemys flavimaculata	Reptile
Turtle, Ringed Sawback	Graptemys oculifera	Reptile
Turtle, Plymouth Red-bellied	Pseudemys rubriventris bangsi	Reptile
Sea turtle, olive ridley	Lepidochelys olivacea	Reptile
Snake, Lake Erie Water	Nerodia sipedon insularum	Reptile
Sea turtle, leatherback	Dermochelys coriacea	Reptile
Snake, Northern Copperbelly Water	Nerodia erythrogaster neglecta	Reptile
Sea turtle, hawksbill	Eretmochelys imbricata	Reptile
Sea turtle, green	Chelonia mydas	Reptile
Turtle, Flattened Musk	Sternotherus depressus	Reptile
Turtle, Alabama Red-bellied	Pseudemys alabamensis	Reptile
Tortoise, Gopher	Gopherus polyphemus	Reptile
Tortoise, Desert	Gopherus agassizii	Reptile
Anole, Culebra Island Giant	Anolis roosevelti	Reptile
Sea turtle, loggerhead	Caretta caretta	Reptile

Appendix G. Submitted Environmental Fate Studies for Saflufeancil.

Table G. Submitted Environmental Fate Studies for Saflufenacil, their Review Classifications, and Issues.

OPPTS Guideline	Submitted Studies (MRID)	Data Requirement	Issues and Comments	Study Classification
835.2120	47127823	Hydrolysis	The co-solvent concentration and limits of detection and quantitation were not reported.	Acceptable
835.2240	47699901	Aqueous photolysis	Limits of detection and quantitation were not reported.	Acceptable
	47127824		Study is replaced by MRID 47699901.	Upgradeable
835.2410	47127825	Soil photolysis	A major transformation product (Product 8, maximum 12.50-16.15% of the applied) was isolated but could not be conclusively identified. Limits of detection and quantitation were not reported.	Acceptable
835.4100	47445901	Aerobic soil metabolism	The extraction procedure appeared to lack rigor. Single samples were collected at most intervals. Limits of detection and quantitation were not reported. The concentration of $^{14}CO_2$ decreased on the final interval.	Acceptable
	47127826		Study is replaced by MRID 47445901.	Upgradeable
835.4200	47611201	Anaerobic soil metabolism	Air-flow to the phenyl-label replicate sample series was uneven. During the anaerobic phase of the study, anaerobic conditions were marginal.	Supplemental
835.4300	47127827	Aerobic aquatic metabolism	Recoveries from the system treated with the uracil label were highly variable. Only one sample was collected at most intervals, so that between-sample variability could not be assessed.	Supplemental
835.4400	47127828	Anaerobic aquatic metabolism	Anaerobic conditions were marginal, as dissolved oxygen concentrations were up to 1.7 mg/L. For the uracil label treatment only, the material balance decreased to an average 69.8-75.7% of the applied at 91-364 days posttreatment. Calculation of the rate of dissipation of saflufenacil has some uncertainty since significant dissipation (35-50% of the applied) of saflufenacil occurred in both systems between the 30 and 62 day sampling intervals. Limits of detection and quantitation were incompletely reported.	Supplemental
835.1230 835.1240	47127829	Batch equilibrium/ aged leaching	Limits of detection and quantitation were not reported.	Acceptable
	47127830		The study was conducted using transformation products of saflufenacil, rather than the parent compound. Levels of detection and quantitation were not reported.	Supplemental

OPPTS Guideline	Submitted Studies (MRID)	Data Requirement	Issues and Comments	Study Classification
835.6100	47127834	Terrestrial field dissipation	None.	Acceptable
	47127835		None.	Acceptable
	47127836		Samples were not analyzed to a sufficient depth to define leaching of saflufenacil at Site 2. Run off of the test compound was not studied at the test sites, although total water inputs exceeded 131% to 846% of the historical average rainfall.	Supplemental
	47128237	Storage stability	None.	Acceptable
	47560309	Storage stability	None.	Acceptable
	47699902/ 47127832	Analytical method in soil	The reported LOQ (0.01 mg/kg) for all analytes is significantly higher than the lowest phytotoxic endpoint in soil.	Supplemental
	47127831		Study is replaced by MRID 47699902.	Upgradeable
835.6200	47127928	Analytical method in water	Submission is incomplete: analytical method cannot be reviewed without an independent laboratory validation.	Upgradeable
	47699903/ 47523803	Analytical method in water	None.	Acceptable
	47523802		Study is replaced by MRID 47699903.	Upgradeable
850.1730	47127909	Fish bioaccumulation	Fish tissue and water samples were not analyzed for [^{14}C]saflufenacil or its transformation products, which lends uncertainty to the study results.	Supplemental

Appendix H. Submitted Ecological Effects Studies for Saflufenacil.

Table H. Submitted Ecological Effects Studies for Saflufenacil, their Review Classifications, and Classification Justifications.

Guideline	MRID	Study Title	Issues	Study Classification
850.2100 (71-1)	47127911	BAS 800 H – Acute Toxicity in the Bobwhite Quail (*Colinus virginiamus*) After Single Oral Administration (LD_{50})	None	Acceptable
850.2200 (71-1)	47127912	BAS 800 H – Acute Toxicity in the Mallard Duck (*Anas platyrhnchos*) After Single Oral Administration (LD_{50})	None	Acceptable
850.2200 (71-2)	47127913	BAS 800 H – Acute Dietary LC_{50} Test in Chicks of Bobwhite Quail (*Colinus virginiamus*)	None	Acceptable
850.2200 (71-2)	47127914	BAS 800 H – Acute Dietary LC_{50} Test in Chicks of the Mallard Duck (*Anas platyrhnchos*)	None	Acceptable
850.2300 (71-4)	47127915 47699904	BAS 800 H – 1 Generation Reproduction Study on the Bobwhite Quail (*Colinus virginiamus*) by Administration in the Diet (including Amendment No. 1)	None	Acceptable
850.2300 (71-4)	47127916	BAS 800 H – 1 Generation Reproduction Study on the Mallard Duck (*Anas platyrhnchos*) by Administration in the Diet	None	Acceptable
850.1075 (71-1)	47127904	BAS 800 H - Acute Toxicity Study on the Rainbow Trout (*Oncorhynchus mykiss*) in a Static System over 96 hours	None	Acceptable
850.1075 (72-1)	47560401	BAS 781 02 H: A 96-Hour Static Acute Toxicity Test with the Rainbow Trout (*Oncorhynchus mykiss*)	None	Acceptable
850.1075 (72-1)	47127905	BAS 800 H: Acute Toxicity Study on the Bluegill Sunfish (*Lepomis macrochirus*) in a Static System Over 96 Hours	None	Acceptable
850.1010 (72-2)	47127901	Acute Toxicity of BAS 800 H to *Daphnia magna* Straus in a 48 Hour Static Test	None	Acceptable
850.1010 (72-2)	47560402	BAS 781 02 H: A 48-Hour Static Acute Toxicity Test with the Cladoceran (*Daphnia magna*)	None	Acceptable
850.1075 (72-3)	47127906	BAS 800 H: A 96-Hour Static Acute Toxicity Test with the Sheepshead Minnow (*Cyprinodon variegatus*)	None	Acceptable
850.1025 (72-3)	47127902	BAS 800 H: A 96-Hour Shell Deposition Test with the Eastern Oyster (*Crassostrea virginica*)	None	Acceptable

Guideline	MRID	Study Title	Issues	Study Classification
850.1035 (72-3)	47127903	BAS 800 H: A 96-Hour Flow-Through Acute Toxicity Test with the Saltwater Mysid (*Americamysis bahia*)	None	Acceptable
850.1035 (72-3)	47560303	BAS 800 H Metabolite M07: A 96-Hour Static Acute Toxicity Test with the Saltwater Mysid (*Americamysis bahia*)	None	Acceptable
850.1400 (72-4)	47127908	BAS 800 H - Early Life-Stage Test on the Fathead Minnow (*Pimephales promelas*) in a Flow-Through System	None	Acceptable
820.1300 (72-4)	47127907	Chronic Toxicity of BAS 800 H to Daphnia magna Straus in a 21-Day Semi-Static Test	None	Acceptable
NA	47127910	Chronic Toxicity of BAS 800 H (Reg. No. 4054449) to the Non-Biting Midge *Chironomus riparius* Exposed Via Spiked Sediment	Non-guideline study	Supplemental
850.3020 (141-1)	47127917	BAS 800 H: An Acute Contact Toxicity Study with the Honey Bee	None	Acceptable
850.3020 (141-1) NA	47445903	Assessment of Side Effects of BAS 800 01 H to the Honey Bee, *Apis mellifera L.* in the Laboratory	Acute Contact – None Acute Oral – Non-guideline	Acceptable Supplemental
850.6200	47127927	Acute Toxicity of BAS 800 H (Reg. No. 4054449) on Earthworms (*Eisenia fetida*) in Artificial Soil with 5% Peat	None	Acceptable
850.6200	47560307	Acute Toxicity (14 Days) of Metabolite of BAS 800 H, M800H08 to the Earthworm *Eisenia fetida* in Artificial Soil	None	Acceptable
NA	47523901	A Rate-Response Laboratory Test to Determine the Effects of BAS 781 02 H on the Parasitic Wasp, *Aphidius rhopalosiphi* (Hymenoptera, Braconidae)	Non-guideline study	Supplemental
NA	47523902	A Rate-Response Laboratory Test to Determine the Effects of BAS 781 02 H on the Predatory Mite, Typhlodromus pyri (Acari: Phytoseiidae)	Non-guideline study	Supplemental
NA	47430803	Effects of BAS 800 01 H on the Predatory Mite (*Typhlodromus pyri*) in a Laboratory Trial	Non-guideline study	Supplemental
NA	47523804	A rate-response laboratory test to determine the effects of BAS 800 01 H on the parasitic wasp, *Aphidius rhopalosiphi* (Hymenoptera, Braconidae)	Non-guideline study	Supplemental
NA	47430801	Effects of BAS 800 01 H on the Activity of Soil Microflora (Carbon Transformation Test)	Non-guideline study	Supplemental
NA	47430802	Effects of BAS 800 01 H on the Activity of Soil Microflora (Nitrogen Transformation Test)	Non-guideline study	Supplemental
850.4400 (123-2)	47127922	Effect of BAS 800 H on the Growth of *Lemna gibba*	None	Acceptable

Guideline	MRID	Study Title	Issues	Study Classification
850.4400 (123-2)	47560302	BAS 800 H Metabolite M07: A 7-Day Toxicity Test with Duckweed (*Lemna gibba* G3)	None	Acceptable
850.4400 (123-2)	47560306	BAS 800 H Metabolite M08: A 7-Day Toxicity Test with Duckweed (*Lemna gibba* G3)	None	Acceptable
850.4400 (123-2)	47560404	BAS 781 02 H: A 7-Day Toxicity Test with Duckweed (*Lemna gibba* G3)	None	Acceptable
850.5400 (123-2)	47127923	Effect of BAS 800 H (Reg. No. 4054449) on the Growth of the Green Alga *Pseudokirchneriella subcapitata*	None	Acceptable
850.5400 (123-2)	47560301	BAS 800 H Metabolite M07: A 96-Hour Toxicity Test with the Freshwater Alga (*Pseudokirchneriella subcapitata*)	None	Acceptable
850.5400 (123-2)	47560305	BAS 800 H Metabolite M08: A 96-Hour Toxicity Test with the Freshwater Alga (*Pseudokirchneriella subcapitata*)	Precipitate in highest test concentration where effects were observed	Supplemental
850.5400 (123-2)	47560403	BAS 781 02 H: A 96-Hour Toxicity Test with the Freshwater Alga (*Pseudokirchneriella subcapitata*)	None	Acceptable
850.5400 (123-2)	47127924	BAS 800 H: A 96-Hour Toxicity Test with the Freshwater Diatom (*Navicula pelliculosa*)	None	Acceptable
850.5400 (123-2)	47127925	Effect of BAS 800 H (Reg. No. 405449) on the Growth of the Blue-Green Alga *Anabaena flos-aquae*	None	Acceptable
850.5400 (123-2)	47127926	BAS 800 H: A 96-Hour Toxicity Test with the Marine Diatom (*Skeletonema costatum*)	None	Acceptable
850.4225 (123-1a)	47127918	BAS 800 02 H: A Toxicity Test to Determine the Effects of the Test Substance on Seedling Emergence of Ten Species of Plants	None	Acceptable
850.4225 (123-1a)	47127919	BAS 800 01 H: A Toxicity Test to Determine the Effects of the Test Substance on Seedling Emergence of Ten Species of Plants	None	Acceptable
850.4250 (123-1b)	47127920	BAS 800 02 H: A Toxicity Test to Determine the Effects of the Test Substance on Vegetative Vigor of Ten Species of Plants	None	Acceptable
850.4250 (123-1b)	47127921	BAS 800 01 H: A Toxicity Test to Determine the Effects of the Test Substance on Vegetative Vigor of Ten Species of Plants	None	Acceptable
850.4100 850.4225 (123-1a)	47560304	Effect of Metabolite of BAS 800 H, M800H07 with Incorporation into Soil on Seedling Emergence of Ten Species of Terrestrial Plants	None	Acceptable
850.4100 850.4225 (123-1a)	47560308	Effect of Metabolite of BAS 800 H, M800H08 with Incorporation into Soil on Seedling Emergence and Seedling Growth of Ten Species of Terrestrial Plants	None	Acceptable